

# **51<sup>st</sup> Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC)**

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## **Independent review of 2010 Stock Assessments of Silver Hake (*Merluccius bilinearis*), Red Hake (*Urophycis chuss*), Offshore Hake (*Merluccius albidus*) and Long fin Squid (*Loligo pealii*)**

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## Executive summary

This report presents an independent scientific peer review of the assessments of two stocks of silver hake (*Merluccius bilinearis*), two stocks of red hake (*Urophycis chuss*) offshore hake (*Merluccius albidus*), and longfin squid (*Loligo pealeii*) carried out at the Stock Assessment Workshops (SAW-51) and presented at the 51<sup>st</sup> Northeast Regional Stock Assessment Review Committee (SARC-51) meeting conducted in November-December 2010.

The meeting proceeded efficiently and was concluded on schedule. The assessment leaders provided clear presentations for each stock and these were followed by constructive dialogue between reviewers, assessment scientists and other SARC participants. The Terms of Reference were clearly defined for each stock, and were all addressed by the assessment working groups even if it was not possible for them all to be met. Uncertainties still remain for the assessments, but managers should consider that the best available science was used in developing the evidence base for biological reference points, stock status and catch advice. Previous research recommendations were reviewed by the assessment working groups, and new recommendations were developed. Additional recommendations are given in this review report.

There have been important advances in the provision of fishery and survey data for these stocks, including preliminary estimates of (minimum) consumption by fish predators allowing the assessments and management advice to be placed in a broader ecosystem context. Considerable efforts have been made, where suitable data were available, to apply analytical assessment models. Since fishing and predation are very size-selective, the development of such analytical approaches and the collection of data to support them is an important area of research. However, the data and understanding of stock dynamics of the three hake species are not yet sufficient for management to be based on such approaches. The advice for the hake stocks, and also for *Loligo*, remains based on abundance indices from the NEFSC spring and fall surveys, together with time-series of fishery landings and discards estimates.

The NEFSC surveys are used in the assessment of many of the demersal stocks off the NE coast, but the design of the survey and the trawl gear is inevitably a compromise that fits some species well but is less than optimal for others. Considerable discussion at SARC-51 focused on the ability of the low headline height survey trawl, used in the NEFSC spring and fall surveys prior to 2009, to provide robust abundance indices for species such as silver and offshore hake which occur over a very broad depth range, feed throughout the water column, and may extend beyond the offshore limits of the survey. Silver hake and *Loligo* also exhibit marked seasonal depth-related changes in distribution which must affect catchability. There is currently very little independent evidence to ground-truth the assumption that trends in survey catch rates of the SARC-51 stocks accurately represent trends in abundance. The SARC has recommended some approaches to help address this.

Conclusions for each stock are summarised below:

### **Silver hake**

The availability of age composition data for the surveys and fishery has provided a major advance for this stock, and the Hake Working Group is to be commended for carrying out very extensive exploration of the available data using the statistical age-structured model ASAP. However, the review panel considered there was no unique model run providing a consistent interpretation of the steep age profiles in the fishery and survey data and the temporal trends in abundance indices. Further work on factors affecting catchability across ages and years in the silver hake surveys is required to ensure that fishing mortality can be resolved from any confounding effects of survey catchability. Management advice continues to be based on a modification of the age-aggregated index method using arithmetic mean survey indices rather than the previous delta method. On this basis the stock is currently not overfished and overfishing is not occurring. Predator consumption estimates included in ASAP show that predation mortality for the sampled fish predators is mainly at ages 0-2 and has varied without trend over time. Consumption data for other predators that may eat larger hake are needed.

### **Red hake**

There are no age composition data for the red hake fishery and survey data, and a number of assessment methods based on length structure were attempted with little success. It did not prove possible to correct the fishery data for historical inaccuracies in identification of red hake and white hake in nominal landings statistics. The evaluation of stock status is based on trends in age-aggregated survey biomass indices and exploitation indices from 1980 onwards, indicating the stock is not overfished and that overfishing is not occurring. This assumes there are no persistent trends in catchability, which needs to be proved. Compilation of a time series of age compositions for the survey and fishery would facilitate analytical assessments in the future.

### **Offshore hake**

This is a data-poor stock with distribution commencing mainly at the offshore limits of the NEFSC survey. Uncertainties in fishery data arise from the need to split mixed-hake landings records between offshore and silver hake. Length composition data are limited and no age compositions are available. Better knowledge of the offshore extent of the stock and the ability of the survey to track abundance trends is needed. The current assessment and review concluded that information is not available to determine stock status, because fishery data are insufficient and survey data are not considered to reflect stock trends. Status is therefore unknown.

### **Long finned squid**

The assessment of *Loligo* is a model-free approach based on NEFSC survey data. Swept-area estimates are converted to absolute biomass using feasible limits for survey catchability components, and compared with fishery catches and estimates of consumption by a subset of fish predators. The conclusion that the biomass has been much larger than the fishery catches, even for the largest feasible survey catchability values, is likely to be a robust conclusion. However, the assertion that the biomass is 5 times lower in spring than in fall depends on an assumption of constant survey catchability across all depths, which requires re-evaluation. Computation of a Bmsy threshold is based on an assumption that historical survey estimates of biomass vary around 90% of carrying capacity, which is an arbitrary high figure. As the threshold is close to the lowest observed annual biomass estimates, the latter could be a more pragmatic argument.

## **1. Background**

This report provides an independent review of the assessments of two stocks of silver hake (*Merluccius bilinearis*), two stocks of red hake (*Urophycis chuss*) offshore hake (*Merluccius albidus*), and longfin squid (*Loligo pealeii*) carried out at the Stock Assessment Workshops (SAW-51) and presented at the 51<sup>st</sup> Northeast Regional Stock Assessment Review Committee meeting. The Review Panel was provided with web access to stock assessment reports and background material prior to the meeting. I then participated in the 51<sup>st</sup> Northeast Regional Stock Assessment Review Committee (SARC-51) meeting to review the assessments. This report includes my own review of the assessment as well as required documentation including the Statement of Work.

## **2. Review activities**

The Review Committee convened at the Laboratory of the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, from 29 November – 3 December, 2010. The Committee comprised a chair and three panel members. Plenary sessions were open to the public.

A formal presentation of the Stock Assessment Workshop (SAW) results was given by the lead analysts from the Hake Working Group (HWG) and the Invertebrate Working Group (IWG), and specific issues were discussed. The analysts returned, when required, for further discussion and clarification of how the SAW Terms of Reference were addressed, including carrying out some additional analyses and model runs for clarification.

Significant time was spent at SARC-51 in reviewing and amending the stock assessment summary reports prepared in draft by the HWG and IWG. The content of the reports including the management advice were discussed and agreed between the Panel and other members of the SARC present at the meeting.

The SARC chair and panel members prepared a first draft of the Panel summary report during the meeting. The panel members were then required to prepare an independent report indicating for each Term of Reference of the relevant SAW: i) whether the work that was presented is acceptable based on scientific criteria (e.g. consider whether the data were adequate and used properly, the analyses and models were carried out correctly, and whether the conclusions are correct/reasonable); and ii) whether the work provides a scientifically credible basis for developing fishery management advice.

There were no disagreements between the panel members on any issues, and therefore my independent review given below to a large extent reflects the Panel's summary report developed at the meeting, with additional comments. Some of the original Panel summary report text has been summarised, or expanded where appropriate, but without changing the Panel's agreed views.

### **3. Acknowledgements**

I would like to thank all the HWG and IWG members present at the meeting for their informative presentations of the SAW results and for providing helpful responses to the SARC's questions and conducting additional analyses. Many thanks also to staff at the Woods Hole Laboratory and particularly to Jim Weinberg and Paul Rago for their hospitality and help throughout the meeting. Many thanks also to the other members of SARC for productive discussions on the assessments.

### **4. Review of individual stock assessments<sup>1</sup>**

#### **A. Assessment of Silver Hake (2 stocks: Northern and Southern)**

##### **A.1 Overview**

A new assessment model for silver hake was proposed this year by the HWG using ASAP (Age Structured Assessment Program). The run proposed as the final run by the HWG gave an interpretation of stock status opposite to the previous and currently updated assessment based only on trends in age-aggregated survey indices. The ASAP run indicates that the stock is currently overfished and that overfishing is occurring, whereas the previous assessment method indicates the stock is not overfished and that overfishing is not occurring. My overall conclusion for this stock is that there are signals in the fishery and survey age composition data that suggest that mortality rates for mature hake could be increasing, despite the very large reductions in fishery catches over time and the apparent steep decline in the exploitation index from the previous method using catch:survey biomass ratios. This is not explained by the existing predator consumption estimates, which are mainly at ages 0 – 2, although there are other predators not yet sampled. However, there are also major issues with regard to interpreting trends from the surveys which use a type of bottom trawl that is sub-optimal for catching hake, having a very low headline height relative to the vertical distribution patterns of hake. Given the known tendency for the distribution of hake to shift progressively into deeper offshore waters with increasing age (as shown by GAM analyses presented in the 2006 assessment), and the apparent shifts in distribution pattern between the northern and southern regions over time, there is a strong possibility for trends of fishing mortality to be confounded with trends in catchability across years and ages. Until this is resolved, it is not possible to conclude that the proposed ASAP assessment provides a reliable assessment of the current status of the stock, although it represents one possible interpretation of stock status.

I conclude that the ASAP model runs presented by the HWG offer valuable insights into the population dynamics signals in the fishery and survey data, and this (or similar approaches) should be developed further. The use of age-structured models also appears appropriate for inclusion of consumption estimates, as the predators and fishery landings and discards have very different selectivity patterns. The most important uncertainty to resolve is the potential for time and age related trends in catchability in the survey and fishery. This would require a more formal evaluation of factors affecting catchability of the survey trawls, using methods such as acoustics

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<sup>1</sup> Any literature references are given at the end of each stock section

to evaluate the proportion of fish of different sizes in the water column that are sufficiently close to the seabed to encounter the nets across the range of depths occupied by the stock. Assessment models should be developed that can allow for survey catchability to drift over time in an explainable manner, or is robust to such changes.

## **A.2. Review of results by Term of Reference**

The extent to which the assessment programme has addressed each of the Terms of Reference for the SAW is evaluated below. The Terms of Reference apply to each stock (Northern and Southern) or combined.

### ***1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.***

This Term of Reference was met in terms of reconstructing historical landings, discards and associated length/age compositions, as far as was possible with available data. The resultant data sets are subject to a number of uncertainties but are adequate for input to the assessment. No information was available on the accuracy of the nominal landings in the early period, particularly for the distant water fishery (DWF).

Fishery effort and LPUE data were not presented due to concerns over the effect of management regulations, however regional time-series of effort data for the main fleets exploiting silver hake would have been valuable for determining regional impacts on the stock and resolving conflicting information on trends in fishing mortality from different assessment runs.

The length-based and depth-based estimators used by the SAW to partition the landings (and discards) of silver and offshore hake based on NEFSC research survey data gave similar results (averaging 94 – 96% of nominal landings for the recent period with species reporting) and are adequate for this species given their predominance in mixed-hake landings. Errors in the species composition estimates are likely to have greater impact on the estimates of the smaller offshore hake catches.

Discards estimates since 1988 are from observer trips using the standard NMFS ratio estimator. The numbers of trips with silver hake discards sampled (Table A25 & A26 in the SAW Report) are patchy and often low. Numbers of trips sampled are small or zero for many fleet – year combinations, implying substantial imputation required to fill in missing estimates. The precision of the estimates should be presented, and the assumption in the ratio estimator that discarded quantities of silver hake are directly proportional to total all-species landings in the sampling strata should be evaluated.

Sampling rates for estimating fishery length compositions were poor until mid – late ‘70s and some years in the mid 1990s have no or very small length samples. Sampling in the south increased substantially in 2000s. Length compositions of discards are relatively poorly estimated and considerable pooling across years has been done. The presentation of sampling rates could be improved by giving numbers of trips sampled for discards and length compositions, in

relation to numbers of trips by the fleet. This would be more informative than numbers measured per 100t, which gives no indication of effective sample sizes given cluster sampling effects.

No fishery age samples were available for inferring catches at age from catches at length. The ALKs from NEFSC surveys were applied to fishery length compositions (landings and discards). The method used for applying survey ALKs to fishery length compositions should be described. Bias of unknown magnitude will be present due to age samples not being directly linked with the fishery length samples from the same trips or hauls or weighted by catch sizes (ICES, 2009). Minimising the biases in age composition estimates would require sampling for length and age from the same fishery hauls, so that both data sets can be analysed following the multistage sampling design and that the age data can be weighted by catch numbers at length in the sampled trips if the age sampling is length stratified and not random. The use of age data collected directly from the fishery is recommended, ensuring that age samples can be linked directly to individual trips.

***2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.***

This ToR was mostly met by the HWG. However, potential biases in the surveys were not sufficiently addressed. I consider that the design, implementation and analysis of the NEFSC survey data were appropriate, although there are aspects of silver hake catchability in the surveys that should have been explored.

A major issue with the silver hake assessment is that the type of trawl gear used on the historical NEFSC trawl surveys may be sub-optimal for hake due to the very low headline height (1 – 2 m). Hake exhibit strong diel vertical migration patterns and tend to feed off bottom. The small demersal trawl on RV *Albatross* with 1-2m vertical opening is likely to have been susceptible to large variations in capture efficiency for hake that may be related to depth, fish size, water temperature, light intensity and location of prey species in the water column. Shifts in distribution of the stock could induce changes in overall catchability across years and ages. Commercial fisheries for hake worldwide tend to use high vertical opening otter trawls, midwater trawls or gillnets that would be expected to improve capture efficiency across a wide depth range. Comments made by fishing industry participants at SARC-51 indicated that the commercial trawls used for silver hake have substantially higher headline height than the research trawls. I recommend a more rigorous evaluation of the catchability of hake taken by the research trawl along the lines of the analysis of the components of catchability for *Loligo pealii* carried out by the Invertebrate Working Group for the 2010 SAW analysis. However, in contrast to the approach adopted by the SAW for *Loligo*, efficiency should be split into two components, one specifying the probability that a hake in the path of the trawl will encounter the net (i.e. related to the position of the hake in the water column, and any factors such as the passage of the vessel causing changes in fish behaviour), and the probability that a hake encountering a given part of the net (doors, bridles, net) will be captured. Field studies would be needed to evaluate the vertical distribution of hake of different sizes in relation to the headline height of the net (for example using multiple frequency acoustics and midwater trawling to identify the targets, and upward-looking transducers on the net), under different conditions of depth, season, time of day,



light intensity etc. An outcome of the proposed study would be the extent to which overall survey age compositions could be affected by age-related depth preferences (leading to domed selectivity), and the extent to which average catchability at each age in the survey could vary over time due to shifts in distribution leading to trends in the depth ranges over which the fish are found. For example, the mean depth across the survey appears greater in the northern region than in the southern region. This work should build on GAM modeling conducted in the 2006 assessment of silver hake which investigated factors affecting apparent distribution of silver hake of different sizes in the NEFSC surveys. Such a study would also provide useful information for other co-occurring species including other hakes.

The spring survey may be particularly susceptible to catchability trends due to the concentration of hake along the shelf edge in deep water. In addition to the problem of vertical distribution in relation to the trawl headline, a portion of the stock may occur offshore of the survey. This may affect the southern region more than the north, due to the greater overall depths across the northern survey area and the more uniform distribution in this area. More information is needed on the offshore extent of the population relative to the survey, using appropriate survey methods. This could be investigated in conjunction with studies on the distribution of offshore hake beyond the limits of the NEFSC survey.

Additional evidence for trends in catchability could come from similarities in survey trends between unrelated but co-occurring species. It is notable that silver hake, offshore hake and red hake (a gadoid species with roughly similar distribution to silver hake in the surveys) have similar trends in biomass index over time (see Fig. A.1 below). The time series of catch rates of silver and red hake are positively correlated in both areas in spring and fall. For example, the catch rates of both species show the same noisy but progressive increase in catch rates in the northern fall survey over most of the series, with a sharp drop in the 2000s. The correlation is weakest for the northern surveys in spring. Silver and offshore hake have similar trends in the south (no data are available for offshore hake in the north), apart from some individual large values for offshore hake in 1980-81. If the trends are driven purely by independent population dynamics rather than factors influencing catchability, this would imply similar patterns of recruitment, growth or consumption mortality (or combination) in both species. Whilst this is possible, it could also indicate trends in processes affecting the catchability of a range of similar species.

If the surveys were accurately tracking population biomass, changes in fishing mortality should be followed by changes in survey biomass estimates. However, the AIM method (see ToR 4) indicated no significant effect of exploitation index (catch/biomass) on the replacement ratio, and several temporal “regimes” were apparent in the relationship between the survey index and exploitation index. This is also evident in red hake and suggests that factors other than abundance are affecting the survey trends, and/or the fishing mortality has been too low for the effects of any changes to be detectable given the variance in the survey indices.

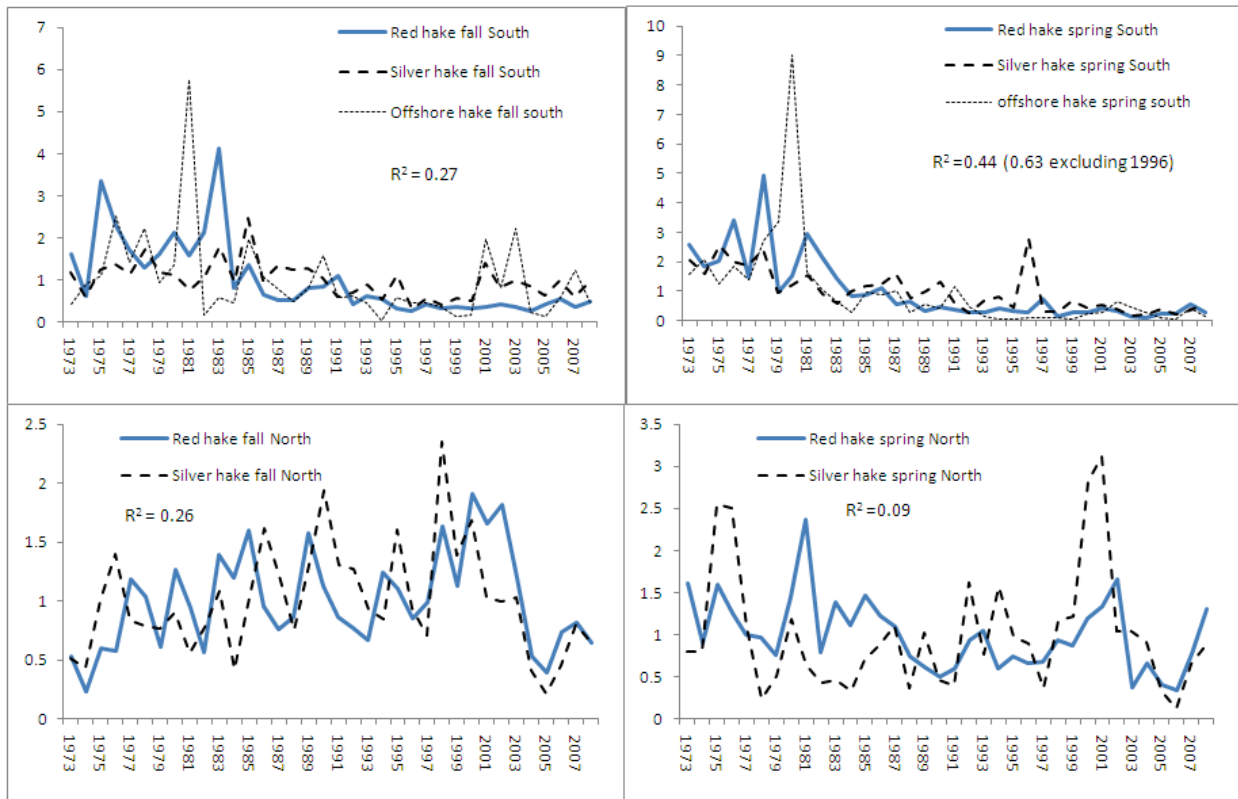


Fig. A.1. Mean-standardised trends in age-aggregated survey biomass indices for silver hake and red hake from NEFSC fall and spring surveys in the north and south, and offshore hake in the south, based on data in the SAW report.  $R^2$  values are for silver vs. red hake.

Information should be provided on sampling rates for estimating age composition in the surveys, and how the data are applied (e.g. the spatial scale at which ALKs are applied). Informal discussion with HWG members indicated that single ALKs were built up for a survey and applied to all stations. As with application of the ALKs to fishery catches, this could lead to bias. I recommend an investigation of the sensitivity of overall survey age indices to (a) weighting age data at each station by the catch rate by length class; (b) pooling age data (without station weighting) within strata and applying to stratum length compositions and (c) pooling age data across several or all strata (without station or stratum weighting). For option (a) in particular, this could lead to many historical stations with no age data or only a proportion of the length classes sampled, requiring substantial imputation which would defeat the purpose of the exercise. As an alternative, the existing survey data could be used to set up a simulation for testing strategies for age sampling and application. One strategy could be to collect a length stratified otolith collection at each station or at random stations in each stratum, to be applied at the station or stratum level with appropriate weighting by station or stratum mean survey catch rates at length (see ICES 2009).

An additional analysis of internal consistency of the survey age compositions (plots of  $N_{a+1,y+1}$  vs  $N_{a,y}$ ) was requested by the Panel. Some relatively strong year classes could be tracked over a few years, but the internal consistency was otherwise relatively poor. This could be a

consequence of applying ALKs in a way that does not account adequately for spatial patterns in age-at-length, errors in ageing, or relatively low recruitment variability resulting in a low signal to noise ratio in the survey catches at age. The use of the survey age material for computing age compositions should be reviewed as suggested above.

The SAW revised the survey index calculation of mean catch rate within survey strata from the previously adopted delta method to using the arithmetic mean of station values. The delta method considers the probability of zero catches separately, and uses logarithms to compute the mean catch rate for positive tows. The SAW noted that the delta method did not reduce the variability in survey indices and noted that if a survey has a high variance, the back-transformation may be biased high. The delta transformation was also considered more sensitive to the handling of missing weights. I support the change to arithmetic mean. Bias corrections to the means of log transformed catch rates require a robust estimate of the standard deviation of the log transformed values, which may not be possible, particularly for strata with small numbers of stations with highly variable catch rates. The delta method may be more appropriate for stocks where the proportion of zero catches is informative in relation to changes in stock size (e.g. stocks such as spiny dogfish that are found in dense aggregations, or stocks recovering from a very low abundance and contracted range).

Since the change in vessel to RV *Bigelow* since the 2009 surveys, a larger otter trawl with a greater vertical opening has been used. There are many other differences in vessel operation, gear and towing procedures including lower towing speed. Differences in catchability at length were estimated from 636 paired tows in 2008, indicating much higher overall catch rates of silver hake in the new net. Catch rates for 10-20cm fish were around 5 – 10 times larger in the new net, but the catch rates for 30cm+ hake were only 1-4 times larger. This implies that the new net would have a more domed selectivity relative to the old net. Eventually the data using the new trawl should be treated as a separate survey series for use in assessments rather than being converted to “Albatross equivalents”.

Several other research surveys were explored by the SAW to provide indices of relative abundance, including a shrimp survey and some inshore surveys. I agree with the SAW in recommending exploration of the other surveys as sensitivity analyses, however the issue of catchability of hake in relation to gear design and spatial survey coverage should also be considered.

Some errors and anomalies in the SAW report related to surveys were picked up by the Panel:

- An error was noted in Table A43. The speed of the net in the spring survey is given as 2 kn. The figures for the spring NEFSC survey and the shrimp abundance survey have been interchanged by mistake, and the correct value for the spring survey is 3.8 kn, the same as in the equivalent fall survey.
- The spring index for 1996 includes a very large spike in numbers of 3-year-olds and overall biomass, which was traced by the analysts at SARC-51 to an unusually large catch of 3-yr-old fish in an offshore stratum in the southern region, with only one tow. The leverage of this outlier on the ASAP fit should be evaluated.

- The calibration factor in Equation (1) on page 16 of the assessment report should be expressed as  $R_B = \rho R_A$  and not  $R_A = \rho R_B$  to be consistent with the data in Fig. A58, as the Bigelow catches have been converted to Albatross equivalents.

**3. *Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.***

This ToR was adequately addressed. I agree with the conclusions of the Hake Working Group that evidence for the existence of separate northern and southern stocks of silver hake is equivocal. Additional information in the form of maps of egg distributions from the MARMAP surveys were provided to the SARC and did not indicate any discontinuity in spawning distributions across the boundary between the northern and southern regions used for the existing stock definition.

**4. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.***

The HWG fully addressed this Term of Reference. The assessment models are appropriate to the data available, and appear to have been applied correctly. However I consider that the model proposed by the HWG is not yet suitable as a basis for developing management advice for reasons outlined below.

Substantial and valuable exploratory work was carried out on the age-based data for the survey, fishery and predator consumption using the statistical age-structured model ASAP (Age Structured Assessment Program). Natural mortality was modeled as a predation mortality component (M2, estimated separately by age and year from predator consumption) and a fixed value of M1=0.15 across all ages and years representing other sources of mortality. The exploratory runs evaluated the effects of choices regarding selectivity at age in the surveys, fishery fleets and the predator “fleet”, including the effects of choices of year blocks for fitting selectivity. The sensitivity to excluding the predator data and using a larger constant M1 across ages was examined.

The main signals in the data affecting the fit of the model were: i) a very steep age profile in the survey and directed fishery age compositions that has become progressively steeper over time, suggesting high and increasing total mortality; ii) age-aggregated survey indices of combined-stock abundance (numbers) that suggest a general increase in total abundance over time up to around 2000 followed by a decline (additional analyses presented to the SARC showed this to be mainly driven by younger hake, whilst numbers of 3+ hake have been declining in the fall surveys). The exploratory ASAP runs provided divergent trends in spawning stock biomass (SSB) and fishing mortality depending on how the model was allowed to fit to the age composition data or the trends in abundance indices. The trends in fishing mortality and SSB from the exploratory ASAP runs tended to cluster into two scenarios: i) declining fishing mortality and generally increasing SSB up to the early 2000s followed by a decline, with the age-

aggregated survey abundance indices following similar trends to the equivalent model estimates; ii) increasing fishing mortality, declining SSB, and a poor fit to the survey abundance indices suggesting a trend of increasing catchability over time in the surveys. The runs yielding scenario (i) were those in which selectivity in the surveys and directed fishery fleet (landings) was allowed the flexibility to be domed rather than fixed to be flat-topped. The runs yielding scenario (ii) were those in which selectivity was fixed to be flat topped.

In scenario (i), the degree of doming in the fishery selectivity was allowed to vary in the different time blocks. This gives additional flexibility to fit the temporal trends in the survey abundance indices by adjusting fishery selectivity over time. A strong survey selectivity dome means that the fitted survey age compositions become more dominated by younger hake, as is observed. In combination, these lead to an apparently good fit to the selectivity-corrected age-aggregated abundance indices from the surveys, whilst also fitting the fishery data well. In scenario (ii), the flat-topped selectivity forces the model to interpret the steep age profiles in the survey and catches as high and increasing mortality rates. However the trade off is that the model estimates of age-aggregated abundance follow different trends to the observed values, showing a declining trend relative to observed values that suggests an increase in survey catchability over time.

Model configurations allowing domed selectivity generate a large “cryptic” (unobserved) population of older hake that have a very low probability of being caught by the fishery or survey. There is currently no evidence for this, and the HWG preferred to force a flat-topped selectivity for the surveys and directed fishery. This model configuration was the basis for the HWG recommending ASAP run 6 in the SAW report as the best interpretation of the data, and this run was used for developing management advice in the SAW report.

Additional runs were presented to the Panel to further explore the sensitivity of the ASAP:

Run 1-1: No consumption estimates included; M1 fixed at 0.5, 0.6 or 0.7.

Run 3-1: Flat top selectivity, with time invariant M2 vector determined as the time series average M2 at age from the run 6 including the predator fleet.

Run 5-1a: Fit using fall survey only, with domed selectivity allowed

Run 5-1b: Fit using spring survey only, with domed selectivity allowed

In Run 1.1, the higher values of M1 reduce the problem of cryptic biomass in the older ages, although this implies losses that cannot at present be attributed to any source. However, there are predators not included in the consumption estimates including marine mammals and seabirds.

Run 3-1 provided results very close to run 6 (HWG’s proposed model), except that there is no longer a period of reduced recruitment early in the time series caused by the lower estimates of consumption at the beginning of the stomach sampling program. Since M2 values from ASAP run 6 appear to vary more or less randomly around fixed values, this suggests that the model could be made more parsimonious (fewer parameters to estimate at the same time) by fixing the M2 values, without altering the trends in abundance and F from the model. However, this approach would reduce the ability to reflect changes in M2 should they occur in future.

Run 5-1a provided results generally similar to run 6 (i.e. scenario (i) with increasing  $F$  and declining  $SSB$ ) despite allowing a dome to be fitted to the fall survey. In this case, the selectivity dome for the survey was not extreme, and the directed fishery selectivity was more-or-less flat-topped. However, retrospective runs showed that the model fit flipped to scenario (ii) with declining  $F$  and increasing  $SSB$  as the terminal year was peeled back, indicating an extremely unstable assessment. This was a clear indication that the data are inadequate to allow selectivity to be freely estimated over all ages in the fishery and survey, including in different fishery time blocks.

The Panel was unable to consider any ASAP run as a suitable basis for providing management advice. Although it appears advisable to fix the directed fishery selectivity on older ages, rather than allowing it to be freely estimated, this leads to strongly autocorrelated trends in survey residuals suggesting there are factors other than abundance affecting survey trends in a non-random way. Information is needed on the existence of year, area or size/age effects on the catchability in the NEFSC surveys, the existence of a “cryptic” biomass, or significant consumption of older hake by predators not yet sampled, to allow objective decisions on the most appropriate ASAP model configuration.

In circumstances where there is a range of model configurations that provide apparently plausible interpretations of the underlying data sets, and that lead to qualitatively different evaluations of stock status or projection results, it may be difficult to identify a unique ‘best estimate’ model run. In this case, it is useful to project each of the runs to examine the sensitivity of management options and evaluate relative risk associated with model choice. Some additional projections were requested by the Panel to compare future stock trends based on ASAP runs 5 and 6 assuming the catch in 2010-2019 is set at the average for the last 10 years (8991mt). These runs are for the domed selectivity (run 5) and flat topped selectivity (run 6) which give opposite stock trends and interpretation of recent stock status. The projections indicate that irrespective of the ASAP run chosen, catches around the recent mean are unlikely to cause stock declines (Fig. A.2).

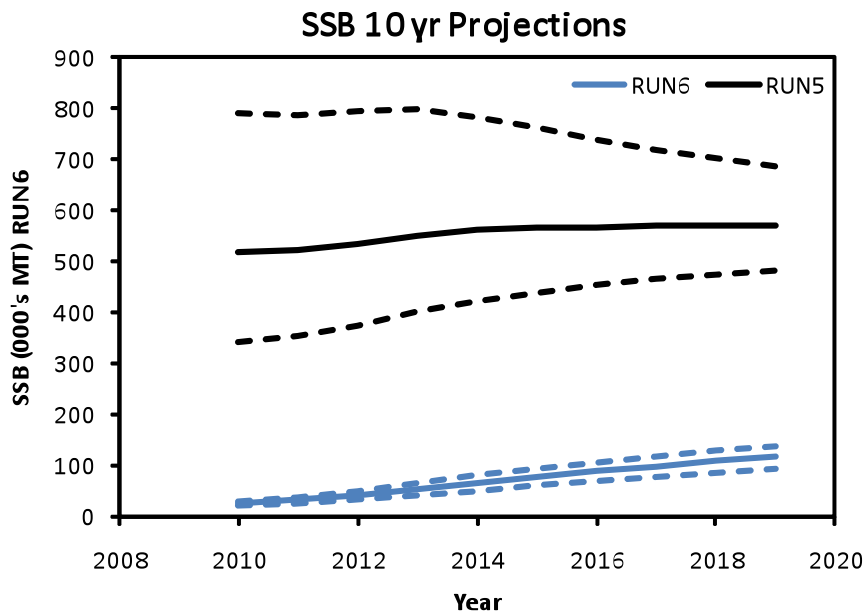


Fig A.2. Results of MCMC SSB projections of ASAP runs 5 and 6 assuming constant annual catch equivalent to mean of last 10 years (additional material requested by the Panels and presented at SARC-51).

An update of the AIM model (An Index Model) was also carried out to evaluate if changes in relative fishing mortality (annual fishery catch divided by the survey biomass index) lead to subsequent coherent changes in the survey biomass index, and to estimate the relative  $F$  at which replacement occurs. No significant relationship was detectable between replacement ratios and relative  $F$ , and several temporal stanzas were evident in the relationship between survey index and relative  $F$ . The results suggest that factors other than fishing are affecting the survey trends, or that  $F$  is too low for the fishery to have a detectable effect. This would also be consistent with evidence from ASAP that catchability in the survey could be changing over time.

***5. Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.***

This ToR was completed. I conclude that the estimates of minimum consumption for the suite of fish predators examined were appropriate for examining the potential magnitude of changes in  $M$  over time, and for evaluating the age profile of  $M$ . The  $M2$  estimates showed no trend over time despite trends in hake biomass. However, the predator consumption estimates must be considered biased in absolute terms, particularly where swept area estimates are used for estimating the absolute abundance of the predators. There may also be temporal trends in bias depending on the trends in abundance and food consumption by predators not included in the estimates. Nonetheless, the consumption estimates are an important finding for ecosystem-based fishery management, and further work should be conducted to refine and expand the estimates, particularly for predators that may eat hake older than 2 years of age. Further consideration of cannibalism dynamics in silver hake is warranted, and how this could be represented in the assessment and forecasts.

**6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.**

The Hake Working Group correctly stated the existing stock status definitions, and met the ToR by proposing new BRPs estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$  based on the ASAP model results. In the absence of an agreed ASAP model run, the BRPs for the northern and southern silver hake stocks were updated at SARC-51 as follows:

- *Silver hake is overfished when the three-year moving average of the fall survey weight per tow (i.e. the biomass threshold) is less than one half the  $B_{MSY}$  proxy, where the  $B_{MSY}$  proxy is defined as the average observed from 1973-1982. The current estimates of biomass threshold for the northern stock is 3.21kg/tow and 0.83kg/tow for the southern stock*
- *Overfishing occurs when the ratio between the catch and the fall survey biomass threshold exceeds 2.78kt/kg for the northern stock area and 52.30kt/kg for the north and southern stock areas.*

This is a development of the existing BRP approach, although now based on arithmetic mean survey indices rather than delta method indices.

**7. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from Silver hake TOR 6).**

This ToR was met. The HWG evaluated stock status based on their preferred ASAP run. However, as this ASAP run was not accepted as a basis for providing management advice, the status of the stock was evaluated at SARC51 based on the revised BRPs from ToR 6.

Under the proposed reference points using arithmetic means to calculate survey indices of abundance, the northern stock of silver hake is not overfished and overfishing is not occurring. The three-year arithmetic mean biomass (Fig. A.3), based on the NEFSC fall bottom trawl survey data for 2007-2009 (6.20kg/tow), was above the proposed management threshold (3.21kg/tow) and below the target (6.42kg/tow). The exploitation index (total catch divided by biomass index, (Fig. A.4) for 2007 – 2009 (1.25kt/kg) was below the threshold (2.78kt/kg). Similarly under the proposed reference points, the southern stock of silver hake is not overfished and overfishing is not occurring. The three-year arithmetic mean biomass (Fig. A.5), also based on the NESFC fall bottom trawl survey data for 2007-2009 (1.11kg/tow), was above the management threshold (0.83kg/tow) and below the target (1.65kg/tow). The exploitation index, (Fig. A.6) for 2007-2009 (7.11kt/kg) was below the threshold (52.30kt/kg).

There are indications from the ASAP assessment, and from declining catch rates at age 3 and older in the fall survey (when hake are more widely distributed over the shelf), that total mortality is increasing. If this is true, the reference points above may no longer be appropriate.



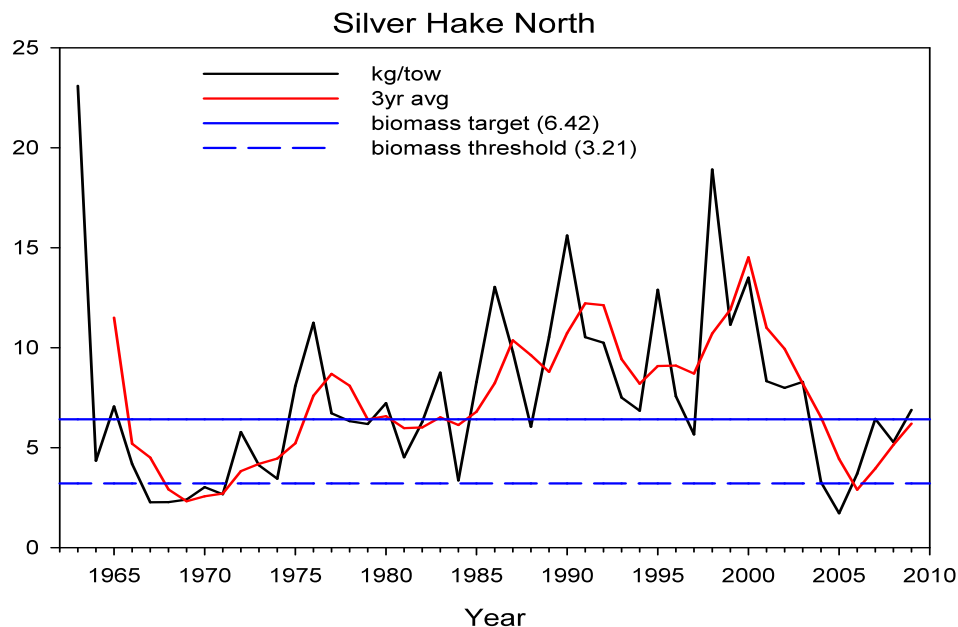


Figure A.3: Fall survey biomass (arithmetic mean) and current biomass reference points for the northern stock of silver hake. (Revised BRPs produced at SARC-51).

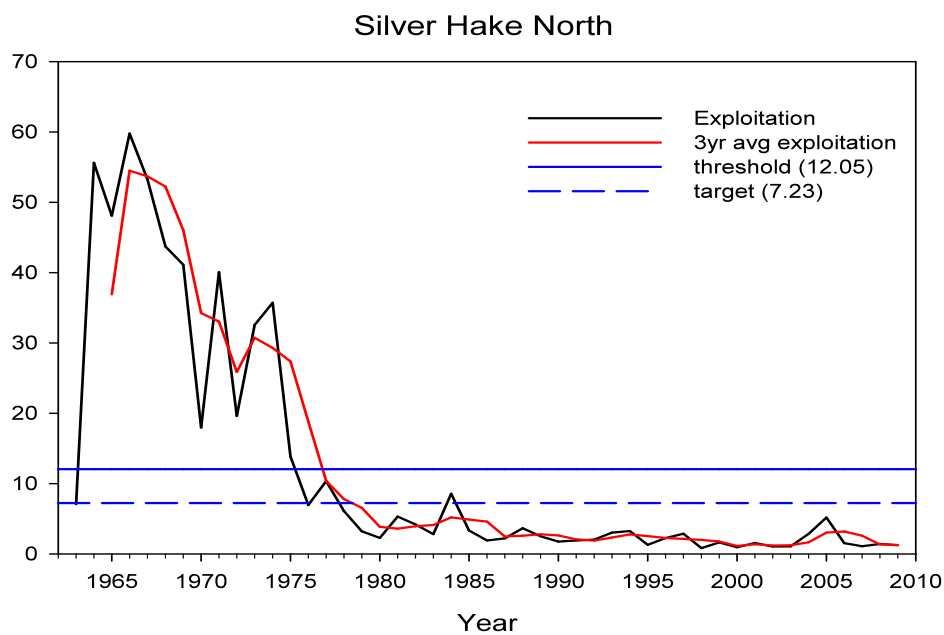


Figure A.4. Exploitation indices (ratio of total catch to fall survey index) and current overfishing threshold and target for the northern stock of silver hake. (Revised BRPs produced at SARC-51).

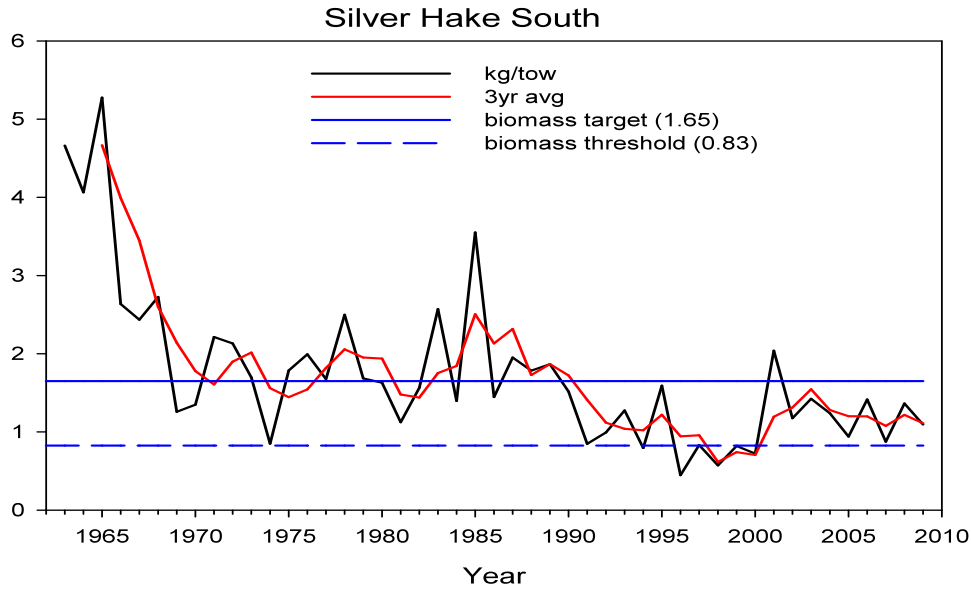


Figure A.5: Fall survey biomass (arithmetic mean) and current biomass reference points for the southern stock of silver hake. (Revised BRPs produced at SARC-51).

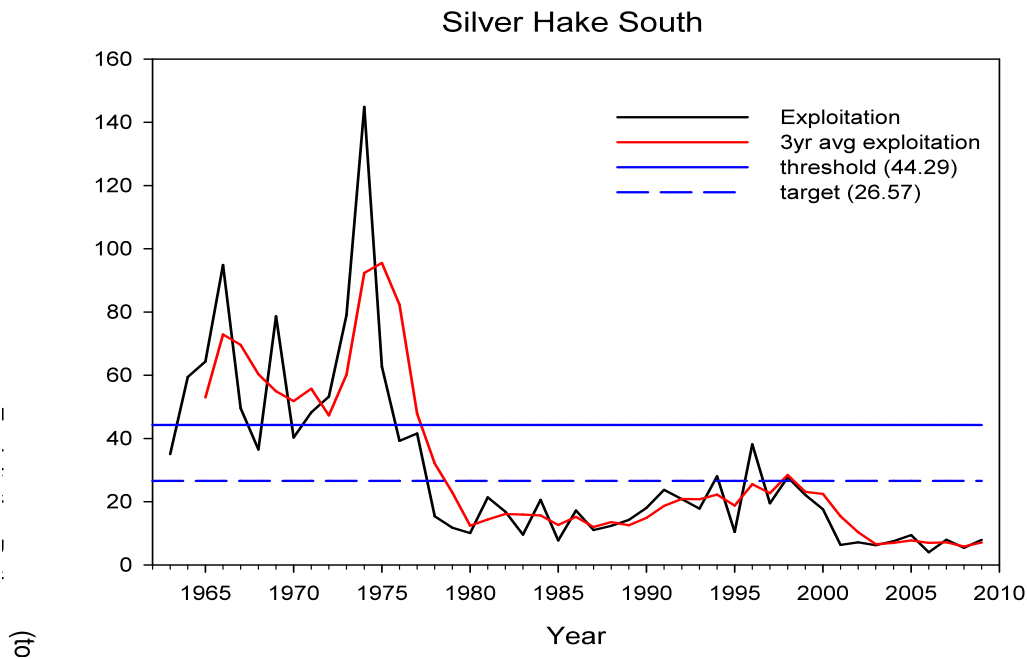


Figure A.6: Exploitation indices (ratio of total catch to fall survey index) and current overfishing threshold and target for the southern stock of silver hake. (Revised BRPs produced at SARC-51).

**8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).**

- a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for *F*, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).**
- b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.**
- c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.**

The ASAP model was not accepted as a basis for providing management advice and so multi-year projections were not possible.

**9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.**

The HWG addressed this ToR by reviewing previous SARC and WG recommendations and their continued validity, and also provided nine new recommendations, one of which was addressed at SARC (use of constant  $M_2$  at age based on the variable estimates in run 6). The new recommendations will improve knowledge of silver hake, but were not prioritised. However the recommendation to estimate discard mortality is probably not necessary, as the experience of commercial trawling, given longer towing time than research trawling, is that the vast majority of hake brought on board are either dead or would not survive return to the water.

I make the following additional research recommendations:

1. Collection and appropriate use of age data directly from the fishery.
2. An evaluation of the current ALK approach to estimating age compositions on the surveys and fishery, and development of methods to minimise bias.
3. Collection of data on size/age related vertical distribution patterns according to depth, area and time of year, for example using acoustics, to allow a more rigorous evaluation of factors such as depth, area and fish size on survey catchability.
4. Given the limitations of trawl surveys for assessing silver hake, consideration should be given to developing other survey approaches such as acoustics or egg production surveys. Applications of the daily egg production method are being developed for European hake (Murua *et al*, 2010). Existing MARMAP data could be reviewed in this context.

5. Consideration should be given to use of linked VMS and landings / sampling data to investigate spatio-temporal effort and cpue and standardized CPUE indices for vessels that fish for silver hake.

## **References**

ICES (2009). Report of the Workshop on methods to evaluate and estimate the precision of fisheries data used for assessment (WKPRECISE), 8-11 September 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:40. 66 pp.

Murua, H., Ibaibarriaga, L., Álvarez, P., Santos, M., Korta, M., Santurtun, M., Motos, L. 2010. The daily egg production method: A valid tool for application to European hake in the Bay of Biscay? Fish. Res. 104, 100-110.

## **B. Assessment of red hake (2 stocks: northern and southern)**

### **B.1 Overview**

The most recent assessments of the two red hake stocks (northern and southern) were conducted during 1990 (SAW 11). These were index-based assessments. The new assessment makes use of fishery landings and discard estimates with associated length frequency data, survey abundance and length frequencies, and estimates of minimum predator consumption for a subset of fish predators with stomach content data collected on the NEFSC surveys. Several assessment methods were attempted: AIM (An Index Method), SCALE(Statistical Catch at Length) and SS3 (Stock Synthesis 3).

The application of these three modeling approaches was built upon considerably enhanced fishery and survey data as well as consumption estimates for major fish predators. This represents a major effort in improving the input data for these (and other species). Nonetheless, red hake remains relatively data poor and the difficulties in fitting analytical assessment models suggests that the data sets and understanding of red hake stock structure and population dynamics need to be further developed. The lack of age composition data for the surveys and fishery remains an obstacle to fitting complex analytical models that have underlying age structure. The biological reference points and management advice continue to be based on simple survey index approaches, which rely on the (largely unproven) assumption that catchability of red hake in the survey is constant, on average, over decades and over large changes in stock size.

### **B.2. Review of results by Term of Reference**

The extent to which the HWG addressed each of the Terms of Reference for the SAW-51 is evaluated below. The Terms of Reference apply to each stock (Northern and Southern) or combined.

***1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.***

This ToR was met in terms of reconstructing historical landings, discards and associated length/age compositions, as far as was possible with available data. Errors in identification of red hake and white hake (*Urophycis tenuis*) in the nominal landings records result in additional uncertainty in landings estimates over and above any historical inaccuracies in overall catch reporting. Results of the length-based method to split commercial catches by species based on research trawl data were not used because of implausible changes to historical data in the northern region. I consider that the nominal landings data probably capture the general trend in the fishery over time, but are subject to the uncertainties due to species misidentification.

Fishery effort and LPUE data were not presented due to concerns over the effect of management regulations. However, presentation of regional time-series of effort data for the main fleets exploiting red and white hake would have been valuable for determining regional impacts on the stock.

The length-based estimator developed by the SAW to partition the commercial landings (and discards) based on the NEFSC research survey data was applied to the mixed landings data as red hake do not grow as large as white hake. The application of this to the landings data resulted in a slight overall reduction in landings in the southern region where the bulk of the fishery has occurred historically, but caused a major change in the landings trend in the smaller northern fishery, and effectively eliminated the large landings peak in the 1970s. I agree with the decision of the HWG to use the nominal landings data for both areas, at least until the reasons for the unusual differences between adjusted and nominal landings in the north are resolved. However this results in an additional uncertainty in the landings data.

Discard estimates have been made since 1988 from observer trips using the standard NMFS ratio estimator. Precision estimates should be presented, and the assumption in the ratio estimator that discarded quantities of red hake are directly proportional to total all-species landings in the sampling strata should be evaluated. The numbers of trips with red hake discards sampled (Table C23 & C24 in the SAW Report) are patchy and often low. Numbers of trips sampled are small or zero for many fleet – year combinations, implying substantial imputation required to fill in missing estimates.

Sampling rates for estimating fishery landings length compositions have been very variable with considerable pooling over years in the northern region. Length compositions of discards are also relatively poorly estimated and considerable pooling across years has been done. The presentation of sampling rates could be improved by giving numbers of trips sampled for discards and length compositions, in relation to numbers of trips by the fleet. This would provide a better indication of effective sample sizes and would be more informative than metric tonnes per 100 lengths, which gives no indication of effective sample sizes given cluster sampling effects. (Note that for silver hake, sampling rates are given as numbers measured per 100 mt. A consistent approach to reporting of sampling rates is encouraged).

No fishery age data were available for inferring catches at age from catches at length.

The HWG discussed in some detail whether there were sufficient fishery data in total to support an assessment or not, without coming to a clear conclusion. The absence of age data means that any form of analytical assessment would have to fit to length composition data. If this was attempted, pooling of length composition data over years would be inappropriate as any year class signals would be smoothed and effective sample sizes would be difficult to specify. Stock Synthesis type models can fit to intermittent length composition data from different fleets, however in the absence of age based survey indices or any fishery age compositions, achieving a solution is likely to be difficult (see ToR 4).

***2. Present the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data***

This ToR was addressed by the HWG, although potential biases in the surveys were not sufficiently addressed. I consider that the survey data provide valuable information on the

seasonal distribution patterns and length compositions, and changes over time. However in the absence of survey age compositions it is difficult to evaluate if successive surveys represent year class variability in an internally consistent way. Therefore it is not possible to know if the surveys are accurately tracking stock abundance.

For silver and offshore hake, the SARC-51 Panel concluded that there is a possibility that catchability between ages and between years in the NEFSC surveys could be strongly influenced by depth-related variation in the trawl capture efficiency. These species have strong diel vertical migration patterns and may also remain far enough above the seabed during daytime, particularly in deep offshore waters, to have low probability of capture in the research trawl, which historically has had a very low headline height (1-2 m). Red hake are gadoids that may have quite different vertical distribution behaviour compared to silver hake. Diel patterns in catch rates in the surveys have not been considered for red hake, and all survey data (day & night) appear to have been used for deriving abundance indices. From the information provided by the HWG, it is not possible to determine if catchability is likely to vary with depth, area, temperature or any other factors. In the silver hake section of this review, I noted that the survey trends for silver, offshore and red hake share common long term trends (Fig. A.1) and that that AIM model results for each species suggest that factors other than abundance could be influencing survey abundance indices over time. The long-term NEFSC survey trends for red hake in the northern and southern regions are different. However, State surveys generally show similar longer term signals to the NEFSC surveys in the same region (Figs C40-41 in the SAW-51 report) despite the noise in the data. For example, the dip in catch rates in the 2000s is common to all the surveys in both the northern and southern surveys. This dip is also noted in silver hake indices for the spring and fall surveys in the north (Fig. A.1). In the absence of an analytical model, or any age composition data to determine if the surveys track year classes in a coherent way, and given the lack of any clear response of survey indices to changes in fishery catches over time, it is difficult to draw any firm conclusions on the ability of the surveys to accurately track abundance of red hake. Data and analyses are needed to ground-truth the assumption of constant catchability.

Since the change in survey vessel from R/V *Albatross IV* to R/V *Henry B. Bigelow* in 2009, a larger otter trawl with a greater vertical opening has been used. There are many other differences in vessel operation, gear and towing procedures including lower towing speed that affect the change-over in the survey time-series. Differences in catchability at length were estimated from 636 paired tows for these two vessels in 2008, indicating around three times higher overall catch rates of red hake in the larger newer net. As with silver hake, the Bigelow:Albatross ratio appears to decline with increasing fish length, although the ratios for individual length classes have wide confidence intervals. This suggests the new net has a different selectivity pattern to the old net. The calibration factors introduce an additional source of uncertainty in the survey time series. Without accurate age composition data to examine offsets in cohort catch curves following the change in gear, it will not be possible to determine if the changes in overall survey indices are consistent with the calibration factors. Ultimately, the Bigelow series should be treated as a separate survey series in any assessment. The calibration factor in Equation (1) on page 11 of the red hake assessment report should be expressed as  $R_B = \rho R_A$  and not  $R_A = \rho R_B$  to be consistent with the data in Fig. C22, as the Bigelow catches have been converted to Albatross equivalents.

The Delta method of handling the survey estimates amplified the variability in the indices rather than reducing it. I agree with the HWG that the calculation of survey indices based on arithmetic

means of station catch rates within survey strata may be more robust for this stock than the use of the delta method, particularly if the variance of log-transformed (non-zero) catch rates is poorly estimated due to small numbers of tows and high variability of catch rates within strata. The delta method may be more appropriate for stocks where the proportion of zero catches is informative in relation to changes in stock size (e.g. stocks such as spiny dogfish that are found in dense aggregations, or stocks recovering from a very low abundance and contracted range). However this does not appear to be the case for red hake. The use of arithmetic means also appears to alleviate problems in estimating weight-based indices where there are missing weight data.

***3 Evaluate the validity of the current stock definition, and determine whether this should be changed. Take into account what is known about migration among stock areas.***

This ToR was met by the HWG. I agree with the conclusions of the Hake Working Group that biological evidence for the existence of a single or two separate (northern and southern) stocks of red hake is equivocal. The split into two stocks was done with analogy to silver hake. While patterns of distribution silver hake spawners can be inferred from the egg and larval distributions of this species, there are three species of *Urophycis* with overlapping distributions and (currently) indistinguishable eggs from which no distributional information by species can be inferred. New information should be sought on stock structure.

***4. Estimate measures of annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.***

The WG fully addressed this Term of Reference, but were not able to fully meet the ToR requirements due to data deficiencies. Substantial exploratory work had been carried out on the length-based data for the survey, fishery and predator consumption using SS3 and SCALE. The methods appear to have been implemented appropriately, but the diagnostics were not adequate for stock status determination and the results are not suitable for the provision of management advice. Comments on the assessment methods are given below.

**AIM:**

The AIM model (An Index Model) was applied separately to the northern and southern stocks to evaluate if changes in relative fishing mortality (indexed as annual catch divided by the survey biomass index) led to subsequent coherent changes in survey biomass index above or below a replacement value. I consider the results to be inconclusive. Using the full time series, there was no significant relationship detectable between replacement ratios and relative F. The relationship between the relative F and survey indices suggested that the functional relationship appeared to be changing over time. This is noted in all the hake stocks in SAW-51. The results suggested that factors other than fishing are affecting the survey trends (e.g. predation or factors affecting catchability), or F is too low for the fishery to have a detectable effect.

Taking into account changes in predator consumption estimates over time, the HWG decided to apply AIM using a truncated time-series from 1980 – 2009. As it is not known how predator consumption translates into natural mortality rate M (in silver hake, the M2 values were



relatively stable over time), this is not necessarily a good argument. A more defensible argument could be that the 1980-2009 series excludes the early period of the northern fishery where there were large inconsistencies between nominal landings and landings estimated from survey species compositions using the length-based method. Inevitably, given the temporal changes in the relationship between survey abundance indices and the relative  $F$  estimates, the truncated series give different results. The effects of truncation are different between the north and south – in the north the early data from the 1967-2009 series are in keeping with the index vs. relative  $F$  slopes in the post 1980s period whereas in the south they lie above the later data. The frequency distributions of correlation coefficient between replacement ratio and relative  $F$  for spring surveys, from the randomisation tests, are not obviously different for the larger southern stock.

The HWG concluded that “*Although none of the randomization tests resulted in significant statistical relationship between the replacement ratio and relative  $F$ , the HWG decided that the results of the shorter series were considered “best” for purposes of reference point proxies and stock status. This was instead of any more subjective look at the survey and catch data at least until an analytical assessment can be developed in the future.*” The results of the AIM run on the truncated spring survey result were carried forward for revisions of the BRPs based on survey indices from 1980 onwards. However, truncation of the series could be seen as a form of “shifting baselines” that can lead to threshold reference points changing in line with stock size.

Although consumption of red hake by key fish predators was not requested as part of the ToR this work was prepared as part of addressing the same issue for silver hake. For red hake, minimum consumption estimates show large year-on-year variations that probably include a substantial estimation error (Fig. C56 in SAW 51 red hake assessment report). There is an indication that consumption was lower in the 1980s than in subsequent decades, although this represents only a subset of potential predators. The ratio of consumption to fishery removals has increased over time as the fishery catches declined in the 1990s.

**SCALE:** Various formulations of the SCALE model were used with the northern stock, southern stock and combined stocks. These included different natural mortalities, the alternative catch series, and different time series. All models had issues with the absence of older ages (sizes) at the end of the time series and lack of fit to the catch at the beginning of the time series. One model run was started from 1980 to avoid the very large early fishery catches but the model did not fit to the declining trend in catch. The model also showed a very strong retrospective pattern. Finally, as consumption cannot be added to SCALE as it is configured, it will no longer be considered as a potential candidate model for this red hake assessment due to the desire to use consumption to scale  $M$ .

**SS3:** The forward-projecting statistical catch-at age model (Stock Synthesis 3 version 3.11c) was applied to estimate fishing mortality rates and stock sizes for the northern stock, southern stock and combined areas. Overall, there were problems in fitting stock-recruit parameters within the model, and fitting the length compositions from the different sources (survey, fishery, consumption) leading to poor model convergence. Therefore, no SS3 models were accepted at this time, although the HWG thought that it was worthwhile to pursue for the next assessment. I agree that, given the data limitations (no age compositions; patchy length compositions; uncertain catches), the stock synthesis approach (or a similar approach tailored to red hake) is

worth pursuing. Such approaches allow for length-based processes such as fishery selectivity and predation selectivity. Revisions of data series should be carried out so that inputs reflect actual data and avoiding extensive imputations for missing data (especially using pooled data over blocks of years to fill gaps, which can smooth out year class signals that the model is attempting to estimate). However, without any age composition data for the fisheries or surveys, there are likely to be continuing difficulties in finding unique solutions.

**5. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.**

The Hake Working Group correctly stated the existing stock status definitions, and met this ToR by proposing new BRPs based on proxies of  $B_{MSY}$  derived from the AIM. I agree that the current definition to identify overfished (i.e. low biomass) stock conditions in the southern stock, based partly on mean weight in the fall surveys, is a better indication of overfishing (high exploitation rate) conditions.

The HWG recommended new BRPs for both northern and southern red hake stocks, based on the truncated (1980-2009) AIM analysis, and these were accepted by SARC-51 as an improvement over the existing BRPs. The overfishing thresholds are the relative F (catch biomass:survey biomass) at replacement, from the AIM model runs. The new BRPs are as follows:

*Red hake is overfished when the three-year moving arithmetic average of the spring survey weight per tow (i.e., the biomass threshold) is less than one half of the  $B_{MSY}$  proxy, where the  $B_{MSY}$  proxy is defined as the average observed from 1980 – 2010. The current estimates of  $B_{threshold}$  for the northern and southern stocks are 1.27 kg/tow and 0.51 kg/tow, respectively.*

*Overfishing occurs when the ratio between catch and spring survey biomass exceeds 0.163 kt/kg and 3.038 kt/kg, respectively, derived from AIM analyses from 1980-2009.*

As noted above, the use of mean survey biomass over 1980-2009 adjusts the target and threshold closer to the relatively low survey indices observed since the 1990s than would be the case if the full survey series was used.

**6. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from red hake TOR 5).**

This ToR was met. The status of the stock was evaluated against the existing BRPs and newly proposed BRPs (see ToR 5). The SARC-51 agreed the evaluation of the HWG, and the stock status is revised as follows (excluding original figure numbers; see Fig. C86 & C87 in SAW-51 red hake report):

*Based on proposed biological reference points, the northern stock of red hake is not overfished and overfishing is not occurring. The three year arithmetic mean biomass index, based on the NEFSC spring bottom trawl survey for 2008-2010 (2.42 kg/tow), was above the proposed management threshold (1.27 kg/tow) and slightly below the target (2.53 kg/tow). The exploitation index (catch divided by biomass index) for 2007-2009 (0.103 kt/kg) was below the threshold (0.163 kt/kg).*

*Based on proposed biological reference points, the southern stock of red hake is not overfished and overfishing is not occurring. The three year arithmetic mean biomass index, based on the NEFSC spring bottom trawl survey for 2008-2010 (0.95 kg/tow), was above the proposed management threshold (0.51 kg/tow) and slightly below the target (1.02 kg/tow). The exploitation index (catch divided by biomass index) for 2007-2009 (1.150 kt/kg) was below the threshold (3.038 kt/kg).*

The stock status has therefore not changed from the previous assessment except for the southern stock for which the overfishing status was previously considered as unknown.

***7. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).***

- a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).***
- b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.***
- c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.***

The SS3 model was not accepted as a basis for providing management advice and so it was not possible to create multi-year projections.

***8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.***

The HWG met this ToR by reviewing previous SARC and WG research recommendations and identifying new recommendations. I agree that the HWGs new recommendations will provide useful information to improve the assessment of red hake. However I am not convinced of the benefits of estimating discard mortality unless there are existing observations to suggest that a significant portion of discards are returned alive to the water in a sufficiently undamaged state. Before embarking on such a study, it would be worthwhile using a suitable run of the stock

synthesis model to explore the effects on management decisions of including a discard mortality estimate, with suitable bounds of uncertainty in the estimates.

The HWG did not prioritize its recommendations. However I suggest that validation of ages and collection and processing of sufficient ageing material should have high priority if further development of analytical assessment methods for this stock is intended. Better knowledge of stock structure is also important, although this is of limited value unless the extent of seasonal mixing of any neighboring stocks or meta-populations is understood.

I suggest the following additional research recommendations:

1. Collection and analysis of suitable data to ground-truth the assumption of constant catchability in the trawl surveys for red hake. This could be embedded in a broader study of size/age related vertical distribution patterns and trawl escapement of hake (and other) stocks according to depth, area and time of year, for example using acoustics and net-mounted, upward looking transducers.
2. Consideration should be given to use of linked VMS and landings/sampling data to investigate spatio-temporal effort and CPUE, and standardized CPUE indices for vessels that fish for red hake.

## **C. Assessment of offshore hake *Merluccius albidus***

### **C.1 Overview**

This is a small stock with very limited data. The HWG has compiled useful information on distribution and size compositions from the surveys and has characterised the fishery as far as is possible with the available data. However, this must be considered a data-poor stock with considerable uncertainties in the fishery catches and in the interpretation of trends in the surveys which mostly cover areas inshore of this hake population. The ability of the low-headline height research trawl on RV *Albatross* to obtain meaningful data on abundance trends for a hake stock in such deep water is also open to question. Attempts to interpret survey catch-rate data and mean length data using AIM and SEINE models were unsuccessful. Assessment of this stock will require different approaches more appropriate to its distribution, behaviour and biology.

### **C.2. Review of results by Term of Reference**

The extent to which the HWG addressed each of the Terms of Reference for the SAW-51 is evaluated below.

#### ***1. Use models to estimate the commercial catch. Describe the uncertainty in these sources of data.***

This Term of Reference was met in terms of reconstructing historical landings, discards and associated length/age compositions, as far as was possible with available data. Prior to 1991, catches of silver hake and offshore hake were not reported separately. Since 1991, landings have been reported by species although the completeness of species reporting has been variable. Offshore hake are found mainly in the southern region and the mixed hake catches in the north were all assumed to be silver hake. I consider there could be large uncertainties in the historical landings estimates related to accuracy of historical nominal mixed-hake landings, particularly those of the distant water fleet, and due to the survey-based methods for allocating mixed hake landings to species. Misallocation between the offshore and silver hake stocks will have a much greater impact on the much smaller offshore hake stock. This is reflected in the larger differences in estimates between the two methods for offshore hake than for silver hake.

Fishery effort and LPUE data were not presented due to concerns over species identification and the effect of management regulations. VMS data could be used to investigate spatio-temporal patterns of fishing effort along the shelf break where offshore hake are found.

Discards estimates since 1988 were obtained from observer trips, using the standard NMFS ratio method to raise observed discards to fleet discards. As with silver hake, the annual numbers of trips has been relatively low and patchy over time, and the accuracy of the ratio estimator should be demonstrated. The precision of the estimates should be presented. Considerable pooling of length compositions of discards across years has been conducted for some fleets and areas.

No age composition data are available for the fishery.

**2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.**

This ToR was met. NEFSC spring and fall survey data were provided only for the southern region. Detailed information on seasonal distribution in the southern region was provided, and age-aggregated abundance indices were developed. Offshore hake catches are mainly in the most offshore strata and an unknown proportion of the stock occurs beyond the survey limits. The same issues with survey trawl capture efficiency and catchability discussed under silver hake will apply to offshore hake, and the efficiency of the Albatross net in particular may be very low in the very deep water where offshore hake are found. Survey coverage is relatively low in the offshore strata with often only one tow per stratum. I consider that the existing survey data may have only limited information for evaluating stock trends and stock status for offshore hake.

In section A (silver hake) I recommended a study should be carried out to determine how factors such as depth, area and fish size affect catchability of silver hake. This would require data on size/age related vertical distribution patterns according to depth, area and time of year, for example using acoustics. A study along these lines could be extended to include offshore hake, including surveying in deeper water to determine the offshore extent of each species in spring and fall.

Given the distribution of offshore hake and the issues concerning catchability in the survey trawl, it cannot be assumed that the survey will provide unbiased data on trends in abundance. Age-aggregated biomass indices for silver hake, red hake and offshore hake (see Fig. A.1 in silver hake section) show similar trends in the southern region during fall and spring. This may suggest that survey indices are strongly affected by factors other than abundance that may have trends over time, although it is possible that all three stocks have the same biomass trends due to similar impacts of fishing, predation and environmental factors affecting recruitment.

Since the change in vessel to RV Bigelow since the 2009 surveys, a larger otter trawl with a greater vertical opening has been used. The conversion factors estimated for silver hake were also used for offshore hake. This is an additional source of uncertainty without accurate age composition data to examine offsets in cohort catch curves following the change in gear.

**3. Estimate measures of annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates.**

The WG addressed this ToR using an analysis of survey biomass trends and trends in mean length of individuals in the surveys. The models appear to have been implemented appropriately, but I agree with the HWG conclusions that the results are not conclusive enough to form the basis for management advice.

The AIM model was applied to examine relationships between relative F (catch:survey biomass index) and replacement ratios and abundance indices, using time series of fishery landings and survey biomass indices. No significant relationship was detectable between relative F and the

replacement ratio. As with silver hake and red hake, the relationship between abundance indices and relative  $F$  appeared to vary over time. This could indicate the trends in survey indices are being strongly influenced by factors other than abundance and catch, and/or that the true  $F$  is too small for any changes to have detectable effect on survey indices. An additional limitation with this analysis is the potentially large uncertainties in the offshore hake landings estimates.

The SEINE model (Survival Estimation in Non-Equilibrium Situations Model) was applied to estimates of mean length in offshore hake survey catches above a defined length threshold. The approach allows for transitory changes in mean length to be modeled as a function of mortality rate changes. The rates of change depend on the von Bertalanffy growth parameters and the magnitude of change in the mortality rates. As there are no existing growth parameter estimates for offshore hake, the HWG used an average of Southern Georges Bank and Southern New England silver hake growth parameters ( $L_{\infty} = 43.91$  and  $k = 0.33$ ). Some length at age data for offshore hake were also used for estimating VB parameters but required a forced value for asymptotic length. A range of threshold length values ( $L_{critical}$ ) were examined for estimating mean length in the surveys, and sensitivity runs were carried out varying the VB growth parameters. The HWG found no correspondence between the mortality rate and the catch (Figures D28-34 in the SAW-51 report) and I agree with their conclusion that the results from SEINE are not a reliable basis for management.

**4. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.**

This ToR was addressed by the HWG. The existing stock status definitions are that “Offshore hake is in an overfished condition when the three year moving average weight per individual in the fall survey falls below the 25<sup>th</sup> percentile of the average weight per individual from the fall survey time series 1963-1997 (0.236) **AND** when the three year moving average of the abundance of immature fish less than 30 cm falls below the median value of the 1963-1997 fall survey abundance of fish less than 30 cm (0.33)”. I agree with the HWG that the mean weight per individual is more an index of overfishing. The utility of such a metric to detect overfishing is cast into some doubt by the results of the SEINE model, which failed to detect any effect of fishery catches on mean length in the surveys.

Survey data may not be a good index of abundance (or of mean weight) and may be driven more by changes in distribution rather than changes in abundance. I agree with the HWG and SARC-51 that no alternative reference points can be recommended and that the existing BRPs should also be rejected. Estimates of catches are highly uncertain and in the absence of a reliable index of stock size, it is not possible to construct biological reference points with such data and therefore it is not possible to evaluate the status of the stock. If a reliable index of stock size were available and if the uncertainty in catches could be reduced, the ratio of catch to index might be a better index of overfishing than using the mean weight.

**5. Evaluate stock status (overfishing and overfished) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from Offshore hake TOR 4).**

The WG addressed this ToR in evaluating stock status with respect to the existing BRPs. Based on the current biological reference points, offshore hake (*Merluccius albidus*) is not overfished and overfishing is unknown. The three year delta individual mean weight index, based on NEFSC fall bottom trawl survey data for 2007-2009 (0.16 kg/individual), is below the management threshold (0.24 kg/individual) but the three year average recruitment index (0.89 num/tow) is above the threshold value (0.33 num/tow).

However, I agree with the conclusions from the current assessment that information is not available to determine stock status, because fishery data are insufficient and survey data are not considered to reflect stock trends. Status is therefore unknown, and the Term of Reference to evaluate stock status with respect to “new” BRPs could not be met as there are no new BRPs proposed.

**6. If a model can be developed, conduct single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).**

- a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for  $F$ , and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).**
- b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.**
- c. Describe this stock’s vulnerability to becoming overfished, and how this could affect the choice of ABC.**

An assessment model could not be developed, and hence no projections were possible.

**7. Propose new research recommendations.**

The HWG proposed ten new research recommendations. As with silver hake, estimation of discard mortality is probably of limited relevance as few fish would be expected to survive from commercial tows in deep water. Recommendations related to survey calibration coefficients also do not seem relevant as no useful data appear to have been collected for this species during the Bigelow vs Albatross catch comparisons. Ultimately the Bigelow series should be treated as separate. The other HWG recommendations are all of interest for addressing shortfalls in knowledge, but are not prioritised.

The HWG recommendations related to the offshore distribution patterns are the most critical for evaluating the utility of the surveys. I propose the following research topics which extend or add to the HWG recommendations:



1. A combined study of the seasonal offshore distribution of silver and offshore hake, including collection of data on the vertical distribution relative to research survey gear.
2. The investigation of alternative survey methods such as acoustics or egg production surveys (e.g. daily egg production method, DEPM) to estimate the biomass of silver and offshore hake (and possibly other species). DEPM surveys would require surveys near peak spawning as well as representative sampling of adults to estimate spawning fractions and batch fecundity. If early-stage eggs of the hake stocks are not identifiable visually, biochemical methods would be needed.

## **D. Assessment of Longfin squid (*Loligo pealeii*)**

### **D.1 Overview**

The assessment of *Loligo* is a model-free approach based on trends in biomass estimates from the NEFSC spring and fall surveys. Possible ranges for absolute biomass each year are investigated by establishing feasible ranges for catchability in the surveys according to trawl deployment parameters and capture efficiency. The resultant biomass estimates are compared with fishery catches and estimates of consumption by a subset of fish predators sampled for diet composition during the NEFSC surveys. The results were used to establish suitable biological reference points for biomass and to infer the possible magnitude of exploitation rate.

The main conclusion of the assessment is that the annual average biomass estimates from the surveys are much larger than the fishery catches, even when calculated using the largest feasible catchability values for the surveys. This is likely to be a robust conclusion. However, the assertion of the Invertebrate Working Group (IWG) that the efficiency of the survey trawl is the same in fall and spring, and hence that the 5-fold difference in catch rates represents equivalent differences in biomass, is a less robust conclusion and requires further analysis.

I consider that the assessment results indicating a probable low exploitation rate, and evaluating trends in biomass, are based on sound data and science and provide an acceptable basis for formulating management advice for *Loligo*.

### **D.2. Review of results by Term of Reference**

The extent to which the IWG addressed each of the Terms of Reference for the SAW is evaluated below.

#### ***1. Characterize the commercial catch including landings, effort, LPUE and discards. Describe the uncertainty in these sources of data.***

This Term of Reference was met to the extent possible given the available data, and a time-series of landings figures were available for the period 1963 – 2009 with partial data for 2010. Discards estimates from observers were available from 1989. There are several sources of uncertainty discussed below. However I agree with the IWG that fishery data from 1987 are sufficiently robust for inclusion in the assessment.

The main uncertainties in the fishery data arise from inaccuracy of landings estimates in the early part of the series, reporting of mixed-species catches as unspecified squid, and the absence of observer estimates of squid discards prior to 1989. The largest uncertainties in landings data are for the years prior to 1987 when the landings were dominated by the offshore distant water (foreign) fleet (DWF) which had no observer coverage prior to 1978 and low coverage thereafter. More accurate landings estimates are available for the US fleet including the offshore fleet which expanded after the DWF was phased out.

An additional source of uncertainty in the historical fishery catches is caused by the need to separate “unspecified squid” landings by species (*Illex illecebrosus* and *Loligo pealeii*) using proration methods. This applies to all catches prior to 1979. Since 1979 part of the US squid landings has continued to be reported as unspecified squid species and has been prorated between species up to 1995. From 1996 onwards the unspecified squid category has been very small and has not been prorated as the majority is expected to have been *Loligo*. The proration method will add to the apparent variability in *Loligo* landings, but are unlikely to change the trends in landings since 1987 to an extent that would invalidate the assessment.

Although observer estimates of *Loligo* discards have only been collected since 1989, the discard rate is low (~3%) and hence the low precision of the estimates (average CV ~ 0.54) will only be a small component of the overall uncertainty in historical catches. The “standard” NEFSC ratio estimator is used for calculating fleet discards from sampled trips, with total multi-species landings used as the auxiliary variable. The SAW report does not present the correlations between *Loligo* discards and the auxiliary variable for the different strata, and hence it is not known if there were biases associated with the ratio method. This should be presented in future assessments.

The estimated catch for the period 1963 – 2010 reached 39 kt in 1973 when the DWF was operating. Catches have declined since 2005 and fell below 10kt in 2009. The recent decline appears related to in-season management. Due to the uncertainties in the historical catches, the IWG decided to use only the catches from 1987-2009 in the assessment. This unfortunately restricts the period over which BRPs can be estimated.

The IWG adequately characterised the seasonality of the fishery in relation to depth and *Loligo* spawning behaviour. The fishery takes place on maturing and spawning squid from a succession of seasonal cohorts that are thought to have a life span of around 6 months. Fishing and spawning mortality occur concurrently during late spring through fall, when spawning *Loligo* and an unknown proportion of their egg masses are taken inshore, in weir and bottom trawl fisheries. The locations of spawning sites at other times of the year, when the fishery operates mainly in deeper offshore waters, are unknown. The large seasonal change in the depth distribution of *Loligo* is an important feature of the assessment, which considers the fishery from July – December to operate on cohorts produced from a spawning peak in spring, whilst the January – June fishery catches mainly cohorts produced the previous fall.

The IWG considers that trends in effort and LPUE data from the fishery are difficult to interpret because of one or more fishery closures during each year since 2000 and the lack of a clear understanding of what the LPUE values actually represent given the complex population dynamics of the species. The SAW report places considerable emphasis on the five-times lower catch rate of *Loligo* in the NEFSC spring survey compared to the fall survey as indicative of lower productivity of cohorts spawned in fall. However, the fishery LPUE data for January-June and July-December (Table B11 in the SAW report) are identical on average and follow similar trends. The IWG did not consider the implications of this for the assessment. There is a possibility that catch rates could be maintained from a less abundant population in spring due to the fleet locating and targeting offshore aggregations, although targeting would also be expected in summer and fall as well. The extent to which fishing activity becomes aggregated could be

investigated using VMS data, and some information on the scales of aggregation of squid in fall and spring could be obtained from the surveys.

The length frequency data collected since 1987 are of variable quality, with improved sampling since 1996. The data are adequate for characterising the size composition of the catches, indicating full recruitment at around 12cm dorsal mantle length (DML). Discards average around 5 – 8cm DML with variations considered related to fishery closures. A figure of 8cm DML is used in the assessment to separate catches into recruits and pre-recruits. This appears a reasonable figure to use.

***2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.***

This Term of Reference was met, and I consider the survey data are adequate for demonstrating interannual changes in distribution and biomass and for exploring a model-free assessment approach. The IWG adequately evaluated uncertainties in the survey data although clearly ran into difficulties in establishing the likely bounds on efficiency of the survey trawl, which required somewhat arbitrary decisions for the lower bound on efficiency. This does not impact any advice based on relative stock trends but any comparisons between median biomass estimates and catches or consumption will be affected by the lower bounds on capture efficiency which are effectively unknown.

The assessment is based around the catch-rates in the NEFSC spring and fall surveys which are considered to encompass the bulk of the *Loligo* populations. The fall survey is considered representative of the average biomass of cohorts produced from a spawning peak in spring, whilst the spring survey is considered representative of the average biomass of cohorts produced the previous fall. Catchability is an important issue due to the vertical migratory habits of *Loligo*, and the IWG devoted considerable work to evaluating components of catchability. However there remains considerable uncertainty in estimates of absolute biomass derived using catchability corrections, due to poor knowledge of the fraction of the squid in the water column that are close enough to the seabed to be caught, particularly in different depths and times of year. The catchability-corrected estimates are most useful for demonstrating a series of “minimum” biomass estimates assuming the highest possible capture efficiency. Relative trends should be relatively robust, although subject to considerable interannual variability.

The IWG provided detailed distribution maps from the surveys illustrating a shelf-wide distribution in fall, with inshore aggregations, and a more offshore distribution in spring close to the offshore boundary of the survey. These patterns were shown to be similar to the seasonal fishery distribution.

In order to reduce additional variance in survey indices caused by diel vertical migration patterns, the data were filtered to include only daytime tows according to the angle of the sun from the zenith. This is an appropriate method to allow for seasonal and latitudinal variations in effective day length. However, if the diel vertical migrations of squid are related to light intensity, the probability of a squid occurring close enough to the seabed to be caught in a bottom

trawl will be lowest in deep water during winter months when the sun is relatively low in the sky and highest in shallow water in summer months when the sun is higher in the sky. This is an issue with the estimation of survey catchability in ToR 3.

The IWG adequately described the within-survey variance by presenting CVs calculated in accordance with the stratified random survey design, assuming that the exclusion of night-time tows does not violate the stratified random design. Figures B25-B28 in the SAW report illustrate the effect on survey trends and CVs of including daytime only tows, and do not indicate a clear and consistent advantage in using daytime only tows if relative trends are being considered. However, as the intention of the IWG was to derive absolute biomass from the survey catch rates using estimates of catchability, it makes more sense to use daytime tows when catchability tends to be highest.

For fish stocks with multiple age classes, the ability of surveys to track abundance accurately can be gauged by the ability to track year class abundance consistently across years. In the case of *Loligo* which live for less than a year, the only time-series link is between pre-recruits in one survey and recruits in the next. Following a request from the panel, the analysts presented a correlation matrix between survey indices within and between years, for recruits and pre-recruits. Both the number and kg per tow indices were significantly correlated for spring and fall surveys carried out in the same year. Correlations between pre-recruits (<8cm DML) and recruits were only significant for spring survey estimates in the same year. Hence there is only limited information to determine if survey trends represent trends in abundance or trends in other factors affecting catchability. The relative trends in the survey indices and the fishery LPUE in spring and fall cannot easily be compared due to the much greater interannual variability in the survey indices, and management measures affecting fishery LPUE, however the fishery trends are encompassed by the survey trends (Fig. D.1).

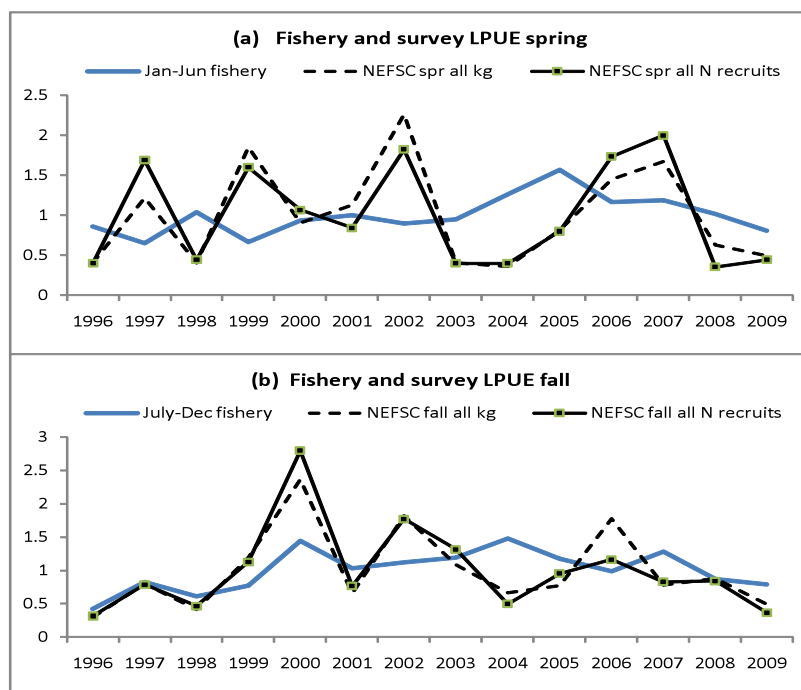


Fig. D.1. Mean-standardised fishery LPUE and survey CPUE for *Loligo*, from data given in the SAW report. The “spring” fishery is January – June and the “fall” fishery is July – December. The “all N recruits” is numbers >8cm DML. The “all kg” is weight

**3. Estimate annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates (consider *Loligo* TOR-4). Include a historical retrospective analysis to allow a comparison with previous assessment results.**

This ToR was addressed based on a model-free analysis of survey data. Although abundance indices for pre-recruits ( $\leq 8$ cm DML) are plotted in the SAW report, these were not used as recruit indices due to the protracted spawning season and subsequent overlap of fast growing cohorts. No population model was attempted therefore no estimates of the “true” fishing mortality are available, and hence exploitation indices (ratio of catch to survey biomass estimates) were calculated. The IWG made a qualitative retrospective comparison of their proposed assessment with previous assessment results, although comparisons were difficult due to differences in methods and input data.

I consider that the assessment presented by the IWG is suitable for developing management advice based on the general level of fishing mortality and on relative trends in biomass. However the conclusions drawn on the absolute biomass (other than the minimum estimates) and on the seasonal changes in biomass are more tenuous due to poor knowledge of the true capture efficiency of the survey nets in different depths and at different times of year.

Biomass was calculated from the NEFSC surveys using feasible ranges for all the components of catchability for *Loligo* in the surveys. This includes area covered by the survey, effective distance towed, door spread, wing spread and trawl capture efficiency. Other than capture efficiency, these parameters can be determined relatively accurately. The bounds for trawl capture efficiency are harder to specify, and the IWG resorted to some video footage of the behaviour of squid encountering trawl gear, and some arbitrary decisions on the lower bounds for efficiency.

Efficiency can be defined as the ratio of number of squid caught in a trawl to the total number in the water column above the swathe of seabed swept by the net or the doors. In practice, capture efficiency should be divided into two components: (a) the proportion of squid in the water column above the trawl swathe that will encounter some part of the gear (doors, sweeps, bridles or net), and (b) the probability that a squid encountering the fishing gear will be captured. The first component is related to the vertical distribution of squid in the water column relative to the net, and any behavioural responses to the passage of the vessel. The second component is related to any escape behaviour on encountering the trawl gear, and will presumably depend on which part of the gear is encountered. For example, using door spread rather than net spread to calculate the area swept could lead to a lower probability of capture because a proportion of the squid will encounter the sweeps or bridles and may avoid these more easily than the net itself.

Only day-time trawls were used to derive survey indices because of the diel vertical movements. The maximum capture efficiency in daytime was defined as 0.95 for the larger net used since 2009 on RV *Bigelow*. The maximum efficiency implies that irrespective of depth or season, effectively all the squid in the water column are close enough to the seabed during daytime to encounter the net and there is virtually no escapement when the net is encountered. The probability of this must be effectively zero. Using the results of the RV *Albatross* vs RV *Bigelow*

calibration trials, which indicated lower squid catch rates in the *Albatross* net, the maximum efficiency of the Albatross net was given as 0.393. Although these values provide relatively robust “maximum” efficiency estimates, the bounds on the minimum capture efficiency were set at an arbitrary value of 0.2 for both nets assuming that “these low-opening survey nets may only be slicing off the lower portion of schools”.

Unless there is knowledge of the actual vertical distribution of squid, the minimum capture efficiency is unknown. This is a particular problem in the deeper shelf-edge habitats in which squid are found in the spring survey. Light intensity near the seabed in these depths in spring will be extremely low and the squid are more likely to be feeding off bottom on myctophids and other mesopelagic fish and crustacea at all times of day. The minimum trawl capture efficiency in deep water is likely to be much lower than 0.2 especially for the *Albatross*’ net which has only a 1 – 2 m headline height. This may explain the five-times lower catch rates in the spring survey than in the fall survey. The mean LPUE of the commercial fishery in January-June and July – December are identical, and the fishery is probably using high headline height trawls.

Bootstrapping was applied to generate probability distributions for survey catchability, drawing random values from the assumed uniform error distributions for each component of catchability. The medians and 25<sup>th</sup> and 75<sup>th</sup> percentiles were used for the biomass calculations, whilst minimum “worst case scenario” biomass was also calculated. Although the bounds for variables such as door spread or distance towed are well defined, the median biomass is a direct consequence of the bounds on capture efficiency, for which the minimum value is unknown.

The IWG compared 6-month fishery catches with the minimum biomass estimates from spring and fall, on the assumption that the ratio can be an index of fishing mortality or exploitation rate. The catch:biomass ratio in fall is very low, suggesting a very low F. The much larger catch:biomass ratio in spring is interpreted by the IWG as a higher fishing mortality on a less productive cohort. I suggest that it may also be a consequence of lower capture efficiency in spring although lower biomass is also possible. Rather than provide management advice separately for spring and fall, the IWG computed an average of the annual spring and fall biomass estimates from the surveys, and compared this with annual catches.

The IWG decision to compute exploitation indices using all sizes of squid in the surveys, not just squid in the size classes represented in fishery catches, is probably not critical if the relative trends over time are the main interest. However the ratio of fishery catch weight (dominated by the much heavier recruits) to survey biomass (dominated by relatively light pre-recruits) is difficult to interpret in absolute terms.

Comparisons with previous assessment results were difficult due to differences in methods and input data using both index-based approaches (NEFSC 1994 assessment) and surplus production models (NEFSC 1996; 1999; 2002 assessments) for *Loligo*. The majority of assessments have relied on relative trends in survey data (NEFSC 1994, 2002 and the current assessment). The stock is now considered lightly exploited but overfishing was determined to be occurring in 2 out of 4 historical assessments. The stock has never been considered overfished, although it was close to its biomass threshold at the time in two cases (NEFSC 1996; 1999). In contrast, the



SAW-51 assessment concludes that both overfishing and overfished stock conditions are unlikely to occur. Given that the assessment is model free no retrospective bias was expected.

**4. Summarize what is known about consumptive removals of *Loligo* by predators and explore how this could influence estimates of natural mortality (M).**

This ToR was met, and I consider that the consumption estimates are extremely useful for demonstrating the potential magnitude of predation and the importance of *Loligo* in the ecosystem, despite the biases acknowledged by the IWG. Preliminary estimates of the seasonal consumption of each of the two primary *Loligo* cohorts were computed using stomach content analysis of fish species taken during the 1977-2009 NEFSC spring and fall surveys. The consumption estimates are viewed as minimum because they only relate to 15 fish predators taken in the NEFSC surveys and do not include cetaceans, birds, large pelagic fish species, or pinnipeds. The estimates are considered preliminary because the ecosystem and predator dynamics in relation to the complex and high turnover rates of squid populations are poorly understood.

The IWG estimated spawning natural mortality ( $M_{sp}$ ) of 0.11 per week and non-spawning natural mortality ( $M_{ns}$ ) of 0.19-0.48 per week for *Loligo* using the methods of Hendrickson and Hart (2006) and the gnomonic method of Caddy (1996), respectively. These were similar to estimates for another northwest Atlantic squid species. Although the methods are only approximate, such high mortality rates are expected as *Loligo* has a short lifespan, with rapid cohort turnover rates and increased natural mortality associated with spawning. Most of the natural mortality is expected to be due to predation, and even the post spawning mortality may be attributed to predation if susceptibility is increased. In the absence of a population model, the estimates of predation cannot be directly compared with the M estimates. However the consumption estimates were 0.8 to 11 times the annual catches during 1977-2009, indicating a relatively high M.

**5. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). Comment on the scientific adequacy of existing BRPs and for the “new” (i.e., updated, redefined, or alternative) BRPs.**

This Term of Reference was met. There are no existing biomass reference points for *L. pealeii*, and I agree with the IWG that the current approach to estimate the  $F_{msy}$  proxy is not appropriate. The proposed new BRPs appear appropriate for supporting fishery management decisions although in the absence of a population model they are not based on any consideration or knowledge of the population dynamics of *Loligo*.

An ad hoc method was used by the IWG to define biomass targets and thresholds based on the median of the annual averages of the spring and fall survey biomass levels during 1976-2008 (76,329 mt). Based on ratios of catch to catchability-adjusted survey biomass estimates, the stock was considered to be lightly exploited and an assumption was therefore made that the 1976-2008 median biomass estimate represented 90% of the stock's carrying capacity ( $K$ ). This leads to a new  $B_{msy}$  target of 50% of  $K$  ( $0.50 \times (76,329/0.90) = 42,405$  mt) and a biomass threshold of 50%



of  $B_{msy}$  (= 21,203 mt). In reality,  $K$  is likely to be non-stationary at decadal scales depending on changes in oceanographic processes on the NE coast shelf and changes in predator abundance and consumption. With no knowledge of the shape or stationarity of the stock-recruit relationship, and given that predation is a dominant source of mortality influencing survival to spawning time, the concept of MSY (and in particular a fixed value of biomass associated with MSY) is probably less appropriate for *Loligo* than for multi-age fish stocks. At best, the proposed approach defines a biomass threshold reference point close to the lowest observed annual survey estimates and could be considered a precautionary reference point on that basis alone (Fig. D.2).

The current  $F_{msy}$  proxy (0.31 per quarter or 1.24 per year) was calculated in the last assessment as the 75<sup>th</sup> percentile of quarterly exploitation indices during 1987-2000. These are no longer considered appropriate by the IWG and SARC-51 due to substantial changes in input data and methodology and because the stock is now considered to be very lightly exploited based on catch:biomass ratios. New fishing mortality reference points are not recommended in this assessment due to the lack of evidence for the impacts of fishing on subsequent annual biomass estimates during 1975-2009. In addition, annual catches were low relative to annual estimates of minimum consumption by a subset of fish predators.

Previous squid assessments for northern short fin squid (*Illex illecebrosus*) and market squid (*Loligo opalescens*) have considered  $F_{40\%}$  (F giving spawning biomass per recruit 40% of the value at zero F) an appropriate proxy for  $F_{msy}$ . This is effectively a spawning escapement per recruit target. SARC 37 acknowledged that the relationship of  $F_{40\%}$  or  $F_{50\%}$  reference points to  $F_{MSY}$  was unknown and was an important topic for future research. A realistic seasonal model of *Loligo* recruitment, growth, predation/spawning mortality, fishing mortality, selectivity and density dependence could allow an exploration of the relationship between fishing mortality and yield and spawning escapement per recruit. Setting up and parameterising such a model should be a priority for developing life-history based BRPs.

**6. Evaluate stock status with respect to the existing BRPs, as well as with respect to the “new” BRPs (from *Loligo* TOR 5).**

This Term of Reference was met. Stock status was evaluated only in respect to the “new” BRPs because there were no previous biomass reference points and the existing  $F_{msy}$  proxy was considered not appropriate for a lightly exploited stock such as *L. pealeii*. I agree with the evaluation of stock status agreed at SARC-51, based on the data from the SAW-51 assessment.

Based on proposed reference points, during 2009, the longfin inshore squid (*Loligo pealeii*) stock was not overfished. Overfishing is not defined because a new overfishing threshold could not be estimated. The two-year average of catchability-adjusted spring and fall survey biomass during 2008-2009 was 54,442 mt (80% CI = 38,452-71,783 mt); higher than the proposed  $B_{threshold}$  proxy currently estimated to be 21,203 mt (Fig. 5.2). The stock exhibits very large fluctuations in abundance (e.g. reproductive success) as reflected in marked changes (2-3 fold) in inter-annual survey biomass estimates. These fluctuations also include the variance of the survey estimates and any year-effects in catchability. I agree with the use of a two-year average to smooth the

noisy annual survey estimates and hence reduce the impact of estimation error on management decisions.

A new threshold reference point for fishing mortality is not recommended in this assessment due to the lack of evidence for the impacts of fishing on subsequent annual biomass estimates during 1975-2009. In addition, annual catches were low relative to annual estimates of minimum consumption by a subset of fish predators. The perception is that the stock is lightly exploited. The 2009 exploitation index (catch in 2009 divided by the average of the spring and fall survey biomass during 2008-2009 = 0.176, 80% CI = 0.124-0.232) was slightly below the 1987-2008 median (0.237) (Fig. D.3). The use of a 2-year smoother is also appropriate for evaluating trends in the exploitation index.

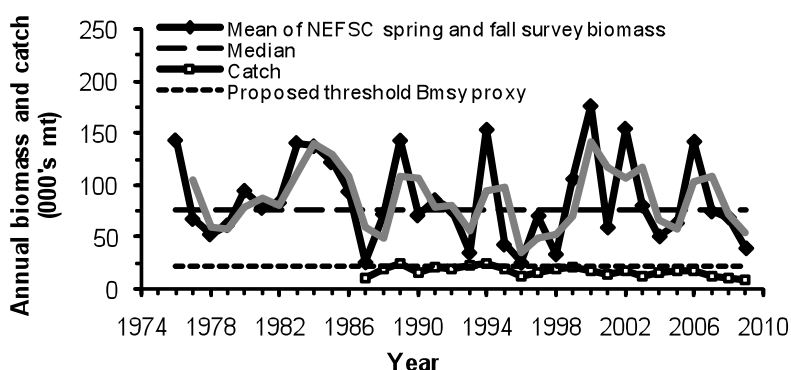


Fig. D.2. Mean annual biomass estimates for *Loligo paeleii* from the NEFSC spring and fall surveys relative to the proposed  $B_{MSY}$  threshold proxy and the annual catch. (Plot prepared for SARC-51 management summary report;  $B_{MSY}$  threshold proxy was not given on the equivalent Figure B40 in the SAW-51 report).

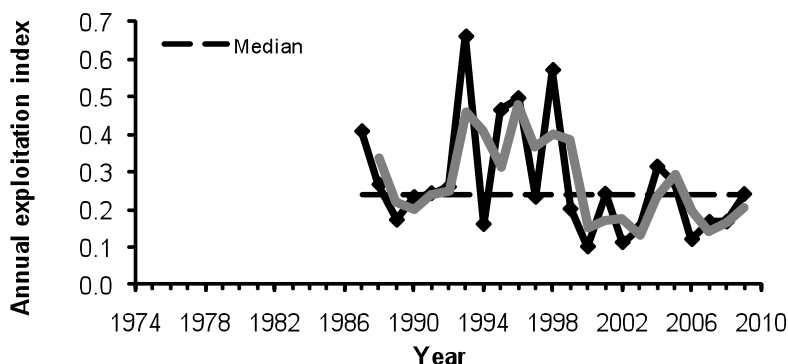


Fig. D.3. Annual exploitation indices (annual catch / average of spring and fall biomass) of *Loligo pealeii*. The grey lines represent the two-year moving averages which, in the top figure, indicates the 2009 value used for stock status determination (Fig. B43 in SAW-51).

The values of the exploitation indices depend directly on the median value of catchability. Other values of catchability would provide different absolute values but the same trends. If the 5-fold reduction in survey biomass estimates in spring compared to fall represents depth-related differences in catchability rather than biomass, the annual exploitation indices (Fig. D.3) will be biased upwards, and the mean biomass values (Fig. D.2) will be biased downwards towards the fishery catches.

***7. Develop approaches for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs), and comment on the ability to perform projections for this stock.***

This ToR was addressed by the IWG, although without providing any clear, practical approaches of immediate use. They considered two aspects of setting ABCs: firstly that it may be prudent to take into account seasonal differences in stock productivity (i.e. implying seasonal ABCs or other forms of seasonal management), and secondly that predator consumption estimates could be factored in. However, a procedure for incorporating predation estimates (which currently cannot be forecasted) was not given, and it is not clear at present the extent to which seasonal survey catch rates are affected by depth-related catchability as the stock distribution shifts between shallow and deep water.

The SAW-51 report indicates clearly why projections are not possible for this stock. SARC-51 adopted the approach of stating that the landings taken annually from the stock after the departure of the distant water fishery did not appear to have impaired the productivity of the stock, and that higher catches could be sustainable.

***8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.***

This ToR was met. Previous research recommendations were reviewed by the IWG and progress on these was briefly documented. The SAW-51 report contains 11 research recommendations although these are not prioritised. The recommendations are all sensible for improving the information needed for assessment and management. However I consider that the following general areas of research are possibly the most urgent. :

1. Quantify the daytime vertical distribution patterns of squid across the occupied depth range in the spring and fall surveys, in order to better understand spatial and seasonal trends in the efficiency of the different survey trawl used in the NEFSC surveys. Upward-looking transducers and/or video could be used to investigate escapement over the headline. This study could be combined with the equivalent recommendation for silver hake.
2. Build a simulation model of the seasonal population dynamics of *Loligo*, representing egg/larval production and subsequent growth and pre-spawning and spawning mortality

due to fishing, predation or other natural causes. Use plausible scenarios including process and estimation error to explore assessment and management options and to identify and prioritise research needs. Possible assessment approaches could include depletion models using short time step abundance indices fitted to a cohort dynamics model, or a two-step biomass model similar to the one developed to assess the South African chokka squid (Roel and Butterworth 2000, Glazer and Butterworth 2006). The simulation model could be elaborated to include spatial dynamics (larval transport and seasonal cross-shelf movements) driven by known oceanographic processes.

3. Collection of data to support the development of the simulation model in recommendation #2. Specifically: seasonal egg production and sexual maturation, and age determination of samples collected on appropriate time intervals.

## References

Glazer, J. P. and D. S. Butterworth, 2006. Some refinements of the assessment of the South African squid resource, *Loligo vulgaris reynaudii*. Fish. Res. 78, 14-25.

Roel, B.A., Butterworth, D.S., 2000. Assessment of the South African chokka squid *Loligo vulgaris reynaudii*. Is disturbance of aggregations by the recent jig fishery having a negative impact on recruitment? Fish. Res. 48, 213–228.

## **5. Critique of NMFS review process**

The inclusion of four stocks in the review process requires considerable pre-meeting evaluation of stock assessment reports and supporting material. These were intended to be available two weeks prior to the meeting, but were mostly not available until one week prior to the meeting. This was insufficient time, particularly for reviewers who have other responsibilities at their home institutes.

Significant time was spent at SARC-51 in reviewing and amending the stock assessment summary reports prepared in draft by the HWG and IWG. The content of the reports including the management advice were discussed and agreed between the Panel and other members of the SARC present at the meeting. The Panel unanimously considered that there was an inappropriate balance between review activities and involvement of the Panel in the advice drafting. The time devoted to revising the advice summary reports (1.5 – 2 days) reduced the time available for the Panel to discuss amongst themselves the review of the assessments and to draft the Panel summary report. It is important that the Panel has sufficient time for this process, not only to agree on the Panel conclusions for the different assessments, but also to discuss and consider recommendations for future research. The latter is an important aspect of the review process, particularly for data-poor stocks and where assessments are being rejected.

## Appendix 1: Bibliography of materials provided for review

### Working Papers Prepared in Support of SARC 51 Terms of Reference

| #                   | Title   | Author                            |  |
|---------------------|---|-----------------------------------|--|
| Silver hake WP#1    | A. Silver Hake Stock Assessment for 2010                  | SAW 51 Hake Working Group         |  |
| Loligo WP#1         | B. <i>Loligo pealeii</i> Stock Assessment Report for 2010 | SAW 51 Invertebrate Working Group |  |
| Red hake WP #1      | C. Red Hake Stock Assessment Report for 2010              | SAW 51 Hake Working Group         |  |
| Offshore hake WP #1 | D. Offshore Hake Stock Assessment for 2010                | SAW 51 Hake Working Group         |  |
|                     |   |                                   |  |

### Background Documents Provided in Support of SARC 51 Terms of Reference

A range of background documents including previous assessment reports were provided on the SARC 51 sharepoint site prior to the review meeting, and a number of papers and reports (mainly for *Loligo*) were placed on the site during the meeting.

## Appendix 2: Statement of Work

### Attachment A: Statement of Work for Dr. Michael Armstrong (CEFAS)

#### External Independent Peer Review by the Center for Independent Experts

#### 51<sup>st</sup> Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Silver, Red, and Offshore hakes, and *Loligo* squid.

#### *Statement of Work (SOW) for CIE Panelists (including a description of SARC Chairman's duties)*

**Scope of Work and CIE Process:** The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from [www.ciereviews.org](http://www.ciereviews.org).

**Project Description** The purpose of this meeting will be to provide an external peer review of benchmark stock assessments for two stocks of silver hake (*Merluccius bilinearis*), two stocks of red hake (*Urophycis chuss*) offshore hake (*Merluccius albidus*), and longfin squid (*Loligo pealeii*). Hake aggregate in large numbers, swim fast, and prey on fish, crustaceans and squid. This review determines whether the scientific assessments are adequate to serve as a basis for developing fishery management advice. Results of this review will form the scientific basis for fishery management in the northeast region. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**. The SARC Summary Report format is attached as **Annex 4**.

The SARC50 review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the SSC of the New England or Mid-Atlantic Fishery Management Council. The SARC panel will write the SARC Summary Report and each CIE reviewer will write an individual independent review report.

**Requirements for CIE Reviewers:** Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the assessment of pelagic stocks and with analyses of survey catchability, particularly for the inclusion of environmental covariates. For the hakes

there are concerns about stock structure, and some issues of species identification in commercial landings (e.g., offshore hake sometimes classified as silver hake). Reviewers should be familiar with methods of stock identification and indirect methods for imputing catch composition (e.g., finite mixture distribution methods). For both *Loligo* and offshore hake, experience with methods for assessing data poor stocks is desirable. Familiarity with the squid life history and the implications of temporally varying natural mortality and growth on population dynamics is also desirable.

In general, CIE reviewers for SARCs shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise should include statistical catch-at-age, state-space and index methods. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers should have experience in development of biological reference points that includes an appreciation for the varying quality and quantity of data available to support estimation of biological reference points.

Each CIE reviewer's duties shall not exceed a maximum of 16 days to complete all work tasks of the peer review described herein.

Not covered by the CIE, the SARC chair's duties should not exceed a maximum of 16 days (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; several days following the open meeting for SARC Summary Report preparation).

**Location of Peer Review:** Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Woods Hole, Massachusetts during 29 November through 3 December, 2010.

**Charge to SARC panel:** The panel is to determine and write down whether each Term of Reference of the SAW (see **Annex 2**) was or was not completed successfully during the SARC meeting. To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. Where possible, the chair shall identify or facilitate agreement among the reviewers for each Term of Reference of the SAW.

If the panel rejects any of the current Biological Reference Point (BRP) proxies for  $B_{MSY}$  and  $F_{MSY}$ , the panel should explain why those particular proxies are not suitable and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs are the best available at this time.

## **Statement of Tasks:**

### **1. Prior to the meeting**

(SARC chair and CIE reviewers)

Review the reports produced by the Working Groups and read background reports.



Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein:

Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email, and FAX number) to the COTR, who forwards this information to the NMFS Project Contact no later than the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide by FAX the requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: <http://deemedexports.noaa.gov/sponsor.html>).

Pre-review Background Documents: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

## **2. During the Open meeting**

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility

arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(SARC chair)

Act as chairperson, where duties include control of the meeting, coordination of presentations and discussion, making sure all Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion. For the assessment, review both the Assessment Report and the draft Assessment Summary Report.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to discuss the stock assessment and to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

(SARC CIE reviewers)

For each stock assessment, participate as a peer reviewer in panel discussions on assessment validity, results, recommendations, and conclusions. From a reviewer's point of view, determine whether each Term of Reference of the SAW was completed successfully. Terms of Reference that are completed successfully are likely to serve as a basis for providing scientific advice to management. If a reviewer considers any existing Biological Reference Point proxy to be inappropriate, the reviewer should try to recommend an alternative, should one exist.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

### **3. After the Open meeting**

(SARC CIE reviewers)

Each CIE reviewer shall prepare an Independent CIE Report (see **Annex 1**). This report should explain whether each Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified above in the "Charge to SARC panel" statement.

If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent CIE Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent CIE Report produced by each reviewer.

The Independent CIE Report can also be used to provide greater detail than the SARC Summary Report on specific Terms of Reference or on additional questions raised during the meeting.

(SARC chair)

The SARC chair shall prepare a document summarizing the background of the work to be conducted as part of the SARC process and summarizing whether the process was adequate to complete the Terms of Reference of the SAW. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the SARC Summary Report (see **Annex 4**).

(SARC chair and CIE reviewers)

The SARC Chair and CIE reviewers will prepare the SARC Summary Report. Each CIE reviewer and the chair will discuss whether they hold similar views on each Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion.

The SARC Summary Report (please see **Annex 4** for information on contents) should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, this report should state why that Term of Reference was or was not completed successfully. The Report should also include recommendations that might improve future assessments.

If any existing Biological Reference Point (BRP) proxies are considered inappropriate, the SARC Summary Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRP proxies are the best available at this time.

The contents of the draft SARC Summary Report will be approved by the CIE reviewers by the end of the SARC Summary Report development process. The SARC chair will

complete all final editorial and formatting changes prior to approval of the contents of the draft SARC Summary Report by the CIE reviewers. The SARC chair will then submit the approved SARC Summary Report to the NEFSC contact (i.e., SAW Chairman).

**Contract Deliverables - Independent CIE Peer Review Reports:** Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**.

**Specific Tasks for CIE Reviewers:** The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

- 1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
- 2) Participate during the panel review meeting at the Woods Hole, Massachusetts during November 29 through December 3, 2010.
- 3) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
- 4) No later than December 17 2010, each CIE reviewer shall submit an independent peer review report addressed to the “Center for Independent Experts,” and sent to Mr. Manoj Shrivani, CIE Lead Coordinator, via email to [shivlanim@bellsouth.net](mailto:shivlanim@bellsouth.net), and to David Sampson, CIE Regional Coordinator, via email to [david.sampson@oregonstate.edu](mailto:david.sampson@oregonstate.edu). Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

**Schedule of Milestones and Deliverables:** CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

|                       |   |
|-----------------------|---|
| 25 October 2010       | CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact                     |
| 15 November 2010      | NMFS Project Contact will attempt to provide CIE Reviewers the pre-review documents by this date                        |
| 29 Nov. – 3 Dec. 2010 | Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA    |
| 2-3 December 2010     | SARC Chair and CIE reviewers work at drafting reports during meeting at Woods Hole, MA, USA                             |
| 17 December 2010      | CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator |
| 20 December 2010      | Draft of SARC Summary Report, reviewed by all CIE reviewers, due to the SARC Chair *                                    |

|                  |  |
|------------------|--|
| 29 December 2010 | SARC Chair sends Final SARC Summary Report, approved by CIE reviewers, to NEFSC contact (i.e., SAW Chairman) |
| 3 January 2010   | CIE submits CIE independent peer review reports to the COTR  |
| 10 January 2010  | The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director          |

\* The SARC Summary Report will not be submitted, reviewed, or approved by the CIE.

The SAW Chairman will assist the SARC chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the SAW Chairman will make the final SARC Summary Report available to the public. Staff and the SAW Chairman will also be responsible for production and publication of the collective Working Group papers, which will serve as a SAW Assessment Report.

**Modifications to the Statement of Work:** Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

**Acceptance of Deliverables:** Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via [William.Michaels@noaa.gov](mailto:William.Michaels@noaa.gov)).

**Applicable Performance Standards:** The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

- (1) each CIE report shall be completed with the format and content in accordance with **Annex 1**,
- (2) each CIE report shall address each ToR as specified in **Annex 2**,
- (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

**Distribution of Approved Deliverables:** Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in \*.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

**Support Personnel:**

William Michaels, Contracting Officer's Technical Representative (COTR)  
NMFS Office of Science and Technology  
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### **Key Personnel:**

#### NMFS Project Contact:

Dr. James Weinberg  
Northeast Fisheries Science Center  
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[James.Weinberg@noaa.gov](mailto:James.Weinberg@noaa.gov) (Phone: 508-495-2352) (FAX: 508-495-2230)

Dr. Nancy Thompson, NEFSC Science Director  
National Marine Fisheries Service, NOAA  
Northeast Fisheries Science Center  
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### **Annex 1: Format and Contents of CIE Independent Peer Review Report**

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Findings of whether they accept or reject the work that they reviewed, and an explanation of their decisions (strengths, weaknesses of the analyses, etc.) for each ToR, and Conclusions and Recommendations in accordance with the ToRs. For each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the Independent Review Report should state why that Term of Reference was or was not completed successfully. To make this determination, the SARC chair and CIE reviewers

should consider whether the work provides a scientifically credible basis for developing fishery management advice.

a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

c. Reviewers should elaborate on any points raised in the SARC Summary Report that they feel might require further clarification.

d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the SARC Summary Report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review

Appendix 2: A copy of the CIE Statement of Work

Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

## **Annex 2: Assessment Terms of Reference for SAW/SARC51 (11/29 – 12/3, 2010)** (file vers.: 4/23/2010)

### **A. Silver hake (2 Stocks: Northern and Southern)**

For each stock or combined,

1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.
2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.
3. Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.
5. Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.
6. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.
7. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from Silver hake TOR 6).
8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
  - d. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for  $F$ , and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
  - e. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
  - f. Describe this stock’s vulnerability to becoming overfished, and how this could affect the choice of ABC.
9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

## **B. Red hake (2 Stocks: Northern and Southern)**

For each stock or combined,

1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.
2. Present the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data.
3. Evaluate the validity of the current stock definition, and determine whether this should be changed. Take into account what is known about migration among stock areas.
4. Estimate measures of annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.



5. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.
6. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from Red hake TOR 5).
7. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
  - a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for  $F$ , and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
  - b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
  - c. Describe this stock’s vulnerability to becoming overfished, and how this could affect the choice of ABC.
8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

### **C. Offshore hake**

1. Use models to estimate the commercial catch. Describe the uncertainty in these sources of data.
2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.
3. Estimate measures of annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates.
4. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.

5. Evaluate stock status (overfishing and overfished) with respect to the existing BRPs, as well as with respect to the “new” BRPs (from Offshore hake TOR 4).
6. If a model can be developed, conduct single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
  - d. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
  - e. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
  - f. Describe this stock’s vulnerability to becoming overfished, and how this could affect the choice of ABC.
7. Propose new research recommendations.

#### **D. Longfin squid (*Loligo*)**

1. Characterize the commercial catch including landings, effort, LPUE and discards. Describe the uncertainty in these sources of data.
2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.
3. Estimate annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates (consider *Loligo* TOR-4). Include a historical retrospective analysis to allow a comparison with previous assessment results.
4. Summarize what is known about consumptive removals of *Loligo* by predators and explore how this could influence estimates of natural mortality (M).
5. State the existing stock status definitions for the terms “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; estimates or proxies for  $B_{MSY}$ ,  $B_{THRESHOLD}$ , and  $F_{MSY}$ ; and estimates of their uncertainty). Comment on the scientific adequacy of existing BRPs and for the “new” (i.e., updated, redefined, or alternative) BRPs.
6. Evaluate stock status with respect to the existing BRPs, as well as with respect to the “new” BRPs (from *Loligo* TOR 5).
7. Develop approaches for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs), and comment on the ability to perform projections for this stock.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

## *Appendix to the SAW TORs:*

### **Clarification of Terms used in the SAW/SARC Terms of Reference**

(The text below is from DOC National Standard Guidelines, Federal Register, vol. 74, no. 11, January 16, 2009)

#### **On “Acceptable Biological Catch”:**

*Acceptable biological catch (ABC)* is a level of a stock or stock complex’s annual catch that accounts for the scientific uncertainty in the estimate of [overfishing limit] OFL and any other scientific uncertainty...” (p. 3208) [In other words,  $OFL \geq ABC$ .]

*ABC for overfished stocks.* For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. (p. 3209)

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)

ABC refers to a level of “catch” that is “acceptable” given the “biological” characteristics of the stock or stock complex. As such, [optimal yield] OY does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

#### **On “Vulnerability”:**

*“Vulnerability.* A stock’s vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality).” (p. 3205)

### **Annex 3: Tentative Agenda**

*The project contact will provide the agenda at least two months before the review. As soon as the agenda is completed it will be sent to the NOAA COTR who will make it available to the CIE. Reviewers should plan to stay for the entire meeting.*

#### **SARC 51 – Fishery stock assessments of silver, red, and offshore hakes, and Loligo squid.**

Woods Hole, Massachusetts during 29 November through December 3, 2010.

## **ANNEX 4: Contents of SARC Summary Report**

1.

The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice. Scientific criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. If the CIE reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

The report may include recommendations on how to improve future assessments.

2.

If any existing Biological Reference Point (BRP) proxies are considered inappropriate, include recommendations and justification for alternative proxies. If such alternatives cannot be identified, then indicate that the existing BRPs are the best available at this time.

3.

The report shall also include the bibliography of all materials provided during the SAW, and any papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

The report shall also include as a separate appendix the Terms of Reference used for the SAW, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

**51st Northeast Regional Stock Assessment Workshop (SAW 51)  
Stock Assessment Review Committee (SARC) Meeting**

**November 29 – December 3, 2010**

Stephen H. Clark Conference Room – Northeast Fisheries Science Center  
Woods Hole, Massachusetts

**DRAFT AGENDA (version: 15 Oct. 2010)**

| TOPIC                         | PRESENTER(S)  | SARC LEADER | RAPPORTEUR |
|-------------------------------|---|-------------|------------|
| <b><u>Monday, Nov. 29</u></b> |   |             |            |
| <b>8:45-9 AM</b>              |   |             |            |
| Welcome                       | <b>James Weinberg</b> , SAW Chair   |             |            |
| Introduction                  | <b>J- J Maguire</b> , SARC Chair  |             |            |
| Agenda                        |   |             |            |
| Conduct of Meeting            |   |             |            |
| <b>9 - 11</b>                 | Assessment Presentation (A. Silver hake)<br><b>TBD</b>                                | <b>TBD</b>  | <b>TBD</b> |
| <b>11- 11:15</b>              | Break   |             |            |
| <b>11:15 - 12:30</b>          | SARC Discussion w/ presenters (A. Silver hake)<br><b>J- J Maguire</b> , SARC Chair    |             |            |
| <b>12:30 - 1:45</b>           | Lunch   |             |            |
| <b>1:45 - 3:45</b>            | Assessment Presentation (B. <i>Loligo</i> )<br><b>TBD</b>                             | <b>TBD</b>  | <b>TBD</b> |
| <b>3:45 - 4</b>               | Break   |             |            |
| <b>4 - 5:15</b>               | SARC Discussion w/ presenters (B. <i>Loligo</i> )<br><b>J- J Maguire</b> , SARC Chair |             |            |

**Tuesday, Nov. 30**

|                  |                                       |            |            |            |
|------------------|---------------------------------------|------------|------------|------------|
| <b>9 - 10:45</b> | Assessment Presentation (C. Red hake) | <b>TBD</b> | <b>TBD</b> | <b>TBD</b> |
|------------------|---------------------------------------|------------|------------|------------|

**10:45 - 11** Break

**11 - 12** SARC Discussion w/ presenters (C. Red hake)  
**J- J Maguire**, SARC Chair

**12 - 1:15**      Lunch

|                 |  |            |            |            |
|-----------------|--|------------|------------|------------|
| <b>1:15 - 3</b> | Assessment Presentation (D. Offshore hake) | <b>TBD</b> | <b>TBD</b> | <b>TBD</b> |
|-----------------|--|------------|------------|------------|

**3 - 3:15** Break

**3:15 - 4:30** SARC Discussion w/ presenters (D. Offshore hake)  
**J- J Maguire, SARC Chair**

**Wednesday, Dec. 1**

**9 - 10:45** Revisit w/ presenters (A. Silver hake)  
**J- J Maguire**, SARC Chair

**10:45 - 11** Break

**11 - Noon** Revisit w/ presenters (B. *Loligo*)  
**J- J Maguire**, SARC Chair

**Noon – 1:15** Lunch

**1:15–2** cont. Revisit w/ presenters (B. *Loligo*)  
**J- J Maguire**, SARC Chair

**2 – 3:45** Revisit w/ presenters (C. Red hake)  
**J- J Maguire**, SARC Chair

**3:45 - 4**      Break

**4 - 5:15** Revisit w/ presenters (D. Offshore hake)  
**J- J Maguire**, SARC Chair



### **Thursday, Dec. 2**

**8:30 - 11**      Review/edit Assessment Summary Report (A. Silver hake)  
**J- J Maguire, SARC Chair**

**11 – 11:15**      Break

**11:15 – 12:15** Review/edit Assessment Summary Report (B. *Loligo*)  
**J- J Maguire, SARC Chair**

**12:15 - 1:30**      Lunch

**1:30 – 2:30**      cont. Review/edit Assessment Summary Report (B. *Loligo*)  
**J- J Maguire, SARC Chair**

**2:30 - 2:45**      Break

**2:45 – 4:15**      Review/edit Assessment Summary Report (C. Red hake)  
**J- J Maguire, SARC Chair**

**4:15 - 5:45**      Review/edit Assessment Summary Report (D. Offshore hake)  
**J- J Maguire, SARC Chair**

### **Friday, Dec. 3**

**9:00 - 5:30 PM**      SARC Report writing. (closed meeting)

\*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public, except where noted.

### **Appendix 3: Review Committee members**

Jean-Jacques Maguire, chair

Mike Armstrong

Beatriz Roel

Geoff Tingley